FLYING AND POPULAR AVIATION

SEPTEMBER

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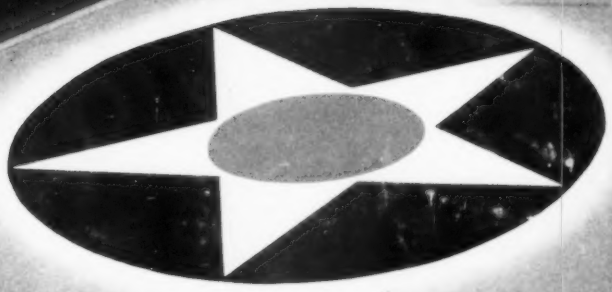

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FLYING
AND POPULAR AVIATION

Special U. S. ARMY AIR FORCES Issue

Volume XXIX Number 3

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● (Below) Spartan Air Corps Fleet at Muskogee, Oklahoma

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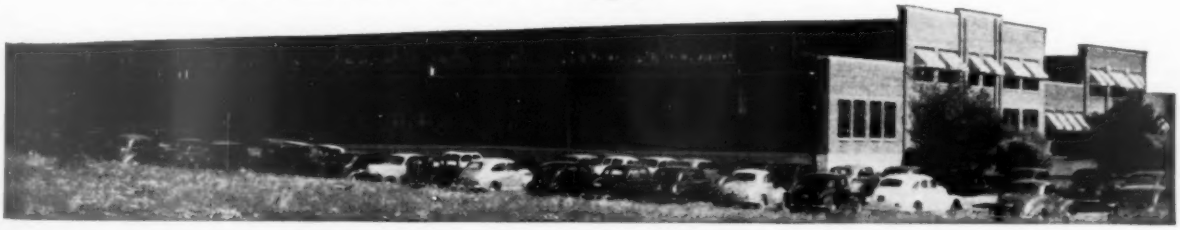

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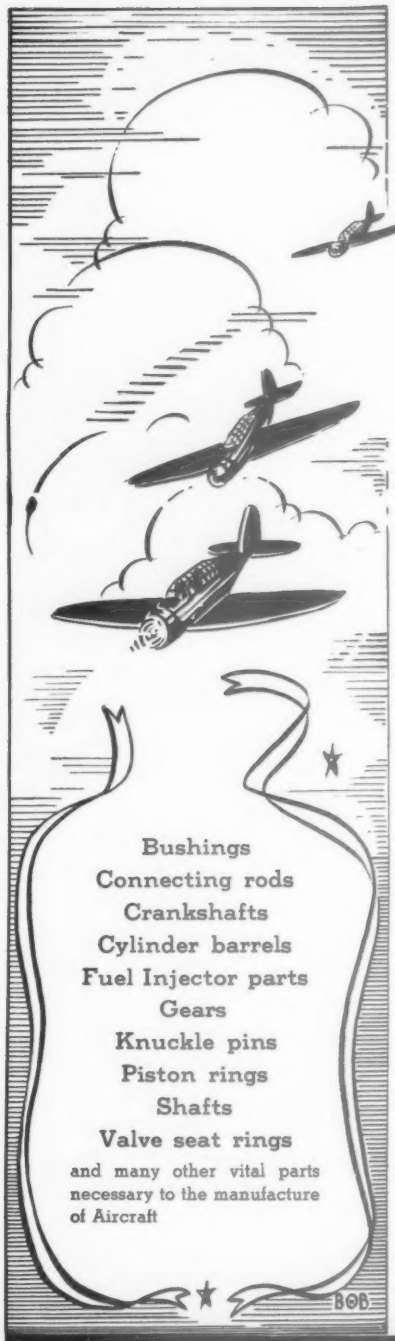

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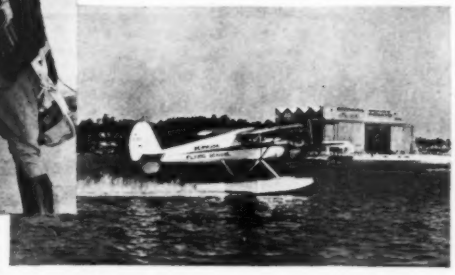

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RCA Model AVR-101 Aircraft Receiver

Similar in appearance and construction to the RCA Model AVR-100. Covers the Weather-Beacon band, 195-405 kilocycles, with excellent performance at extremely low cost. Like the AVR-100, it can be used for direction-finding with AVA-122 directional loop.

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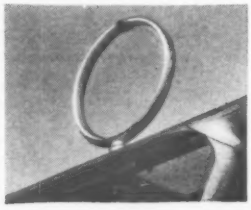

RCA Model AVA-122 Directional Loop Antenna

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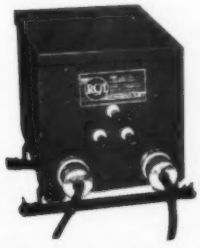

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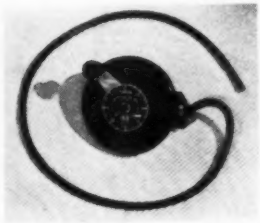

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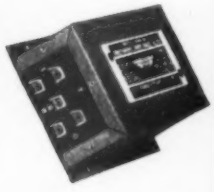
Only RCA builds this de luxe type trailing antenna system. Combines all the experience and features known to the art. Free wheeling brake, turns counter, shock proof design, non-leaking fair lead and high altitude operation.



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Matter of fact, I have too much time on my hands—on evenings and weekends.

The nearest village is 5 miles away. All you find there is a general store, a garage and a canning factory—nowhere to go for any good clean fun, unless you drop in at a smoke-filled juke joint on the way.

Well, Mom, there's a big favor you can do me. The U. S. O. is trying to raise $10,765,000 to run clubs for us, outside of camp. Places with lounge rooms, dance floors, games, writing rooms. Places you can get a bite to eat without paying a king's ransom.

I know you don't have an idle million lying around, but if you could get the family interested and some of the neighbors, and if that happened all over the country, the U. S. O. could raise $10,765,000 overnight.

I'd appreciate it a lot, Mom, and so would every other mother's son in the U. S. Army and Navy.

Love,
Bill

They're doing their bit for you. Will you do your bit for them? Send your contribution to your local U. S. O. Committee or to U. S. O., Empire State Building, New York, N. Y.

OPEN YOUR HEART
OPEN YOUR PURSE
GIVE TO THE

U ★ S ★ O ★

UNITED SERVICE ORGANIZATIONS

These organizations have joined forces to form the U.S.O.: the Y.M.C.A., National Catholic Community Service, Salvation Army, Y.W.C.A., Jewish Welfare Board, National Travelers Aid Association.

THIS SPACE CONTRIBUTED BY THE BG CORPORATION

1916 B & W: BOEING'S FIRST AIRPLANE, A SEAPLANE TRAINER

1919 BOEING B-1: USED IN FIRST INTERNATIONAL AIR MAIL SERVICE

1923 BOEING PW-9: FIRST PURSUIT WITH ELECTRIC WELDED STRUCTURE

1926 F2B-1: BOEING'S FIRST AIR-COOLED FIGHTER FOR NAVY CARRIERS

1927 BOEING 40-A: PIONEER TRANSCONTINENTAL MAIL-PASSENGER PLANE

1928 BOEING 80: 12-PASSENGER, TRIMOTORED TRANSPORT PLANE

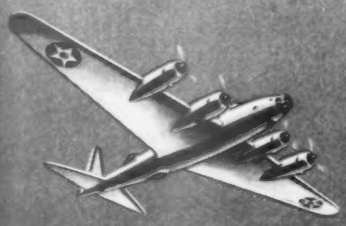
1928 BOEING F4B-1: THE PROTOTYPE OF A FAMOUS ARMY-NAVY FIGHTER SERIES

1930 BOEING MONOMAIL: FIRST OF MODERN STREAMLINED TRANSPORTS

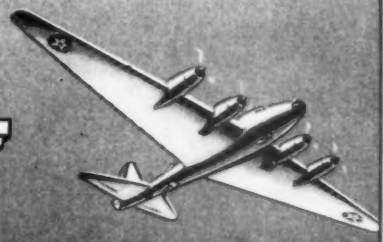
1931 BOEING YB-9: FIRST ALL-METAL, TWIN-ENGINE BOMBER, STARTING NEW DESIGN TREND

1932 BOEING P-26: IN ITS DAY, THE FASTEST AIR-COOLED FIGHTER IN THE WORLD

1933 BOEING 247: FIRST MODERN TWIN-ENGINE TRANSPORT, INTRODUCING TODAY'S DESIGN



1935 BOEING 299: AMERICA'S FIRST 4-ENGINE BOMBER – ORIGINAL FLYING FORTRESS



1937 BOEING B-15: FIRST EXTRA-LONG RANGE BOMBER – FORERUNNER OF CLIPPERS

25 YEARS of AGGRESSIVE LEADERSHIP – BACKGROUND FOR TODAY'S EMERGENCY

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WICHITA, KANS.

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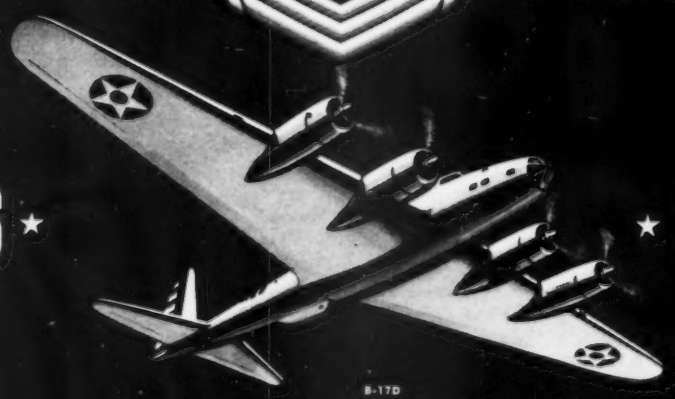
1939 BOEING 307: STRATOLINERS – WORLD'S FIRST AND ONLY HIGH-ALTITUDE TRANSPORTS

★1916★

★1941★



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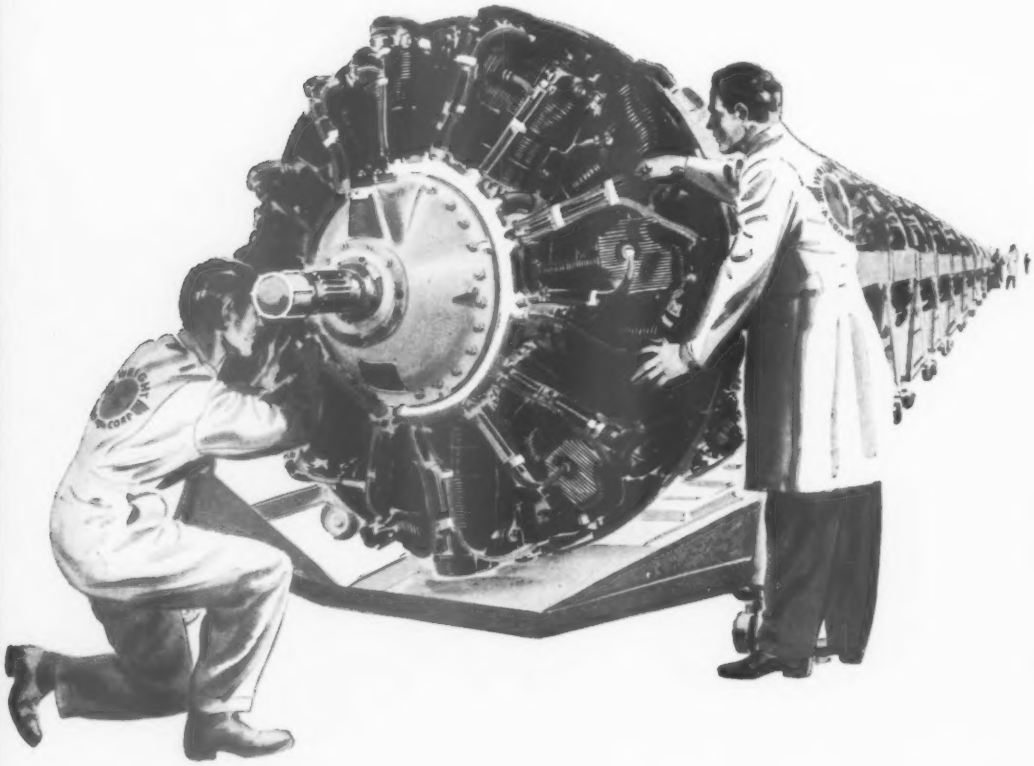

Cyclone 14's ROLL OFF THE LINE

ONE YEAR AFTER INCEPTION OF WRIGHT PLAN

JUST A YEAR after the approval of the original proposal by the Defense Commission, Cyclone 14's are rolling off the line at the Wright Cincinnati Plant. Presented to the Government in June, 1940, this proposal led the way for the thousands of contracts which followed and "The Wright Plan", developed by Wright and Government officials, became the model after which these contracts were patterned.

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WRIGHT AERONAUTICAL CORPORATION • PATERSON, NEW JERSEY

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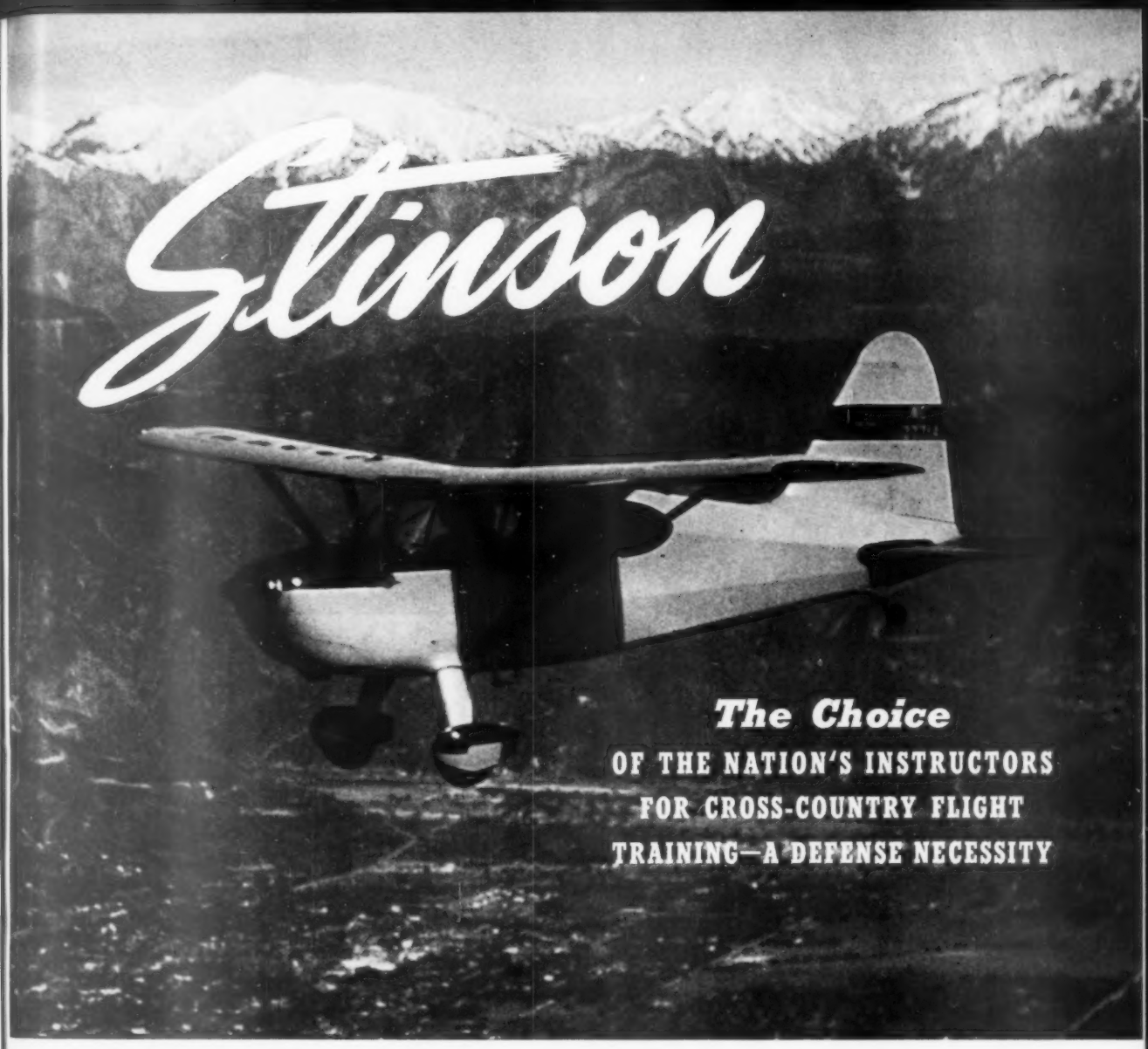

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Preliminary Instruction. Preparation for your first flight. Communication and signals. The engine and propeller. Straight and level flight. Turns. Confidence building maneuvers. Taxiing. Glides. Stalls. Banks. Eights. Rectangular course. Take-offs. Landings. Solo.

Intermediate Maneuvers. The different eights. Precision turns. Steep gliding and climbing turns. Tight spirals. Key position. Precision landings. Forward slips. Side slips. Cross wind takeoffs and landings. Down wind landings.

Advanced Maneuvers. Chandelle. Lazy eights. Wingover. Advanced stall. Falling leaf. Precision spins. Loops. Snap roll. Vertical reverse. Cuban eight. Split-S. Immelman. Slow roll. Roll on top of loop.

The Private Pilot. Requirements. Shallow or steep eights. Triangulation spirals. Flying 180°, U, 360° overhead, elementary 1080°, advanced 1080°. Stalls. Spins. 720° steep bank. Other maneuvers. Written examination questions and answers, including Civil Air Regulations, navigation, meteorology.

The Commercial Pilot. Requirements. Flying master pilot eight. Precision maneuvers. Night flying. Training in Aerobatics. Commercial pilot flight test. Written examination questions and answers, including operation of plane, theory of flight, engines, navigation, meteorology.

Cross-Country Flying. Pre-flight duties—planning, plane and instrument checking, fuel and oil, weather, flight plan, notifications on departure. In-flight duties—log, cruising speed, charts and position, weather changes, what to do in forced landings, check on instrument readings, radio contacts, arrival. Post-flight duties—reports, care of ship. Flight errors. Procedure when lost.

Airways Radio. C.A.A. instrument landing system. Illustration—Indianapolis system. Radio Compass navigation. Magnetic and radio compass deviation. Variation. Homing. Combined radio-range and radio compass navigation. Questions and answers from typical examination for restricted radio-telephone operator's permit.

Instrument Flying and Rating. Required maneuvers. Instrument flying course. Instrument rating examination questions and answers, including radio, orientation, Civil Air Regulations, radio and instrument flying, meteorology.

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The Birdmen's Perch

We're old friends, so I suppose we can speak frankly. Now honestly, fellows, was last month's problem too tough for you? Are you ready to cry "Uncle"? If you are, just write and let me know—we'll go back to easy "Brain-Twisters" again.

Major Al Williams, alias "Tattered Wing Tips,"
Gulf Aviation Products Manager, Gulf Bldg., Pittsburgh, Pa.

FUNNYBONER DEPT.

The following Aviation Primer was authored by Russ Brinkley of Station WHP, Harrisburg, Pa. Not bad, Russ!

Q: What is a wing flap?
A: An aileron on relief.

Q: Describe a successful landing.
A: Any landing you can walk away from.

Q: What is the last word in parachutes?
A: Jump!

Q: Define an amphibian.
A: A combination eagle, chicken, and duck.

A: What is aeronautical amnesia?
Q: Instrument flying.

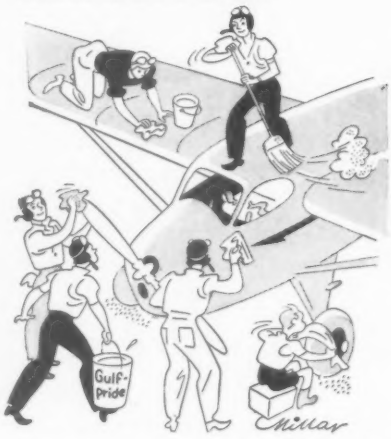
THIS MONTH'S BRAIN TWISTER

Clifford Crankshaw of Detroit, Mich., sends in this "brain-blitz," as he calls it, for you to work on:

An air taxi operator paid $90,000 for a fleet of planes, each costing the same amount. Five of the planes crashed and he sold 20% of the remainder for one-sixth of his original investment.

How many planes did he buy and how much did he pay for each?

FLYING HOUSEKEEPERS



The other day we dropped off at the airport at Hartford, Conn. It was one of those bright spring days—perfect for flying—that really bring the sports pilots out.

We lay there on the grass, watching them as they practiced take-offs and landings, and suddenly we were struck by the fact that every plane seemed as spic and span as though it had just come off the assembly line. And then looking over at the hangar, where most of the pilots kept their planes, we saw—a great big GULF sign!

What's the moral? Simply this: A pilot who takes pride in the appearance and condition of his plane, thinks about the *inside* as well as the outside. These pilots were mostly Gulfpride users. Because they know that one of the best ways to keep an engine clean and sweet-running is to use an oil that has been specially refined so as to be resistant to carbon and sludge formations. They know that Gulfpride is refined from *special crudes*—by our special Alchlor Process—a process which removes *more* of the engine fouling carbon and sludge formers.

Of course you take pride in your plane. And *we* take a great deal of pride in being able to produce an oil like Gulfpride for pilots like you!

THIS MONTH'S WHOPPER

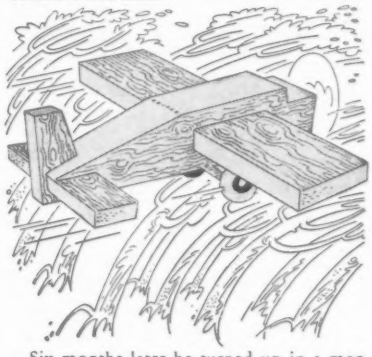
Dear Major,

It happened in the banana country of Panama. His name was Wilbur . . . (deleted by censor.)

When I wandered through the jungle into his home, he was testing his second plane. He even had a home-made field. The runway was carefully graded—6 feet wide by 100 feet long and 150 foot jungle trees right up to the edge.

Since the termites were bad, he constructed this ship from the tropical wood, Copobolo, which is impervious to insects and about twice as heavy as lead. To start with, the fuselage used four by fours with four by four braces. This was covered with 1 inch planking (all toe-nailed in). The controls took bailing wire, while the joy stick was carved out of a piece of Copobolo that I could not reach around with both hands. He had a French Monosoupapa motor for power, about 80.

I slipped a gallon of Gulf Aviation Gasoline into his kerosene tank, and watched him take off. He went through those trees so fast that they fell right back on their trunks! He was headed toward a big ditch at (0) degrees altitude. I heard the next day that the government was going to pay him for digging the new locks for the Panama Canal, but they couldn't find him.



Six months later he turned up in a monastery in the Khyber Pass, chewing a lead pencil and saying over and over, "I woulda went further but that G.A.G. was so strong all the cylinder heads blew off and I got tired sticking my hands over each piston in the firing order."

Yours truly,
Kenneth W. Byars,
Ex. U.S.N. '43.

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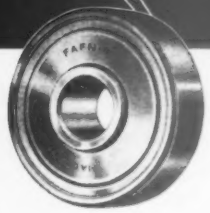

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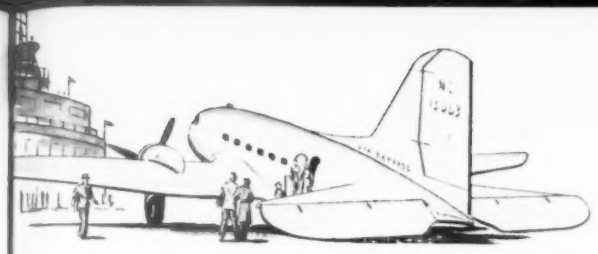

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lines. Below, Douglas C-47, U.S. Army cargo
rrier. These are basically identical airplanes.

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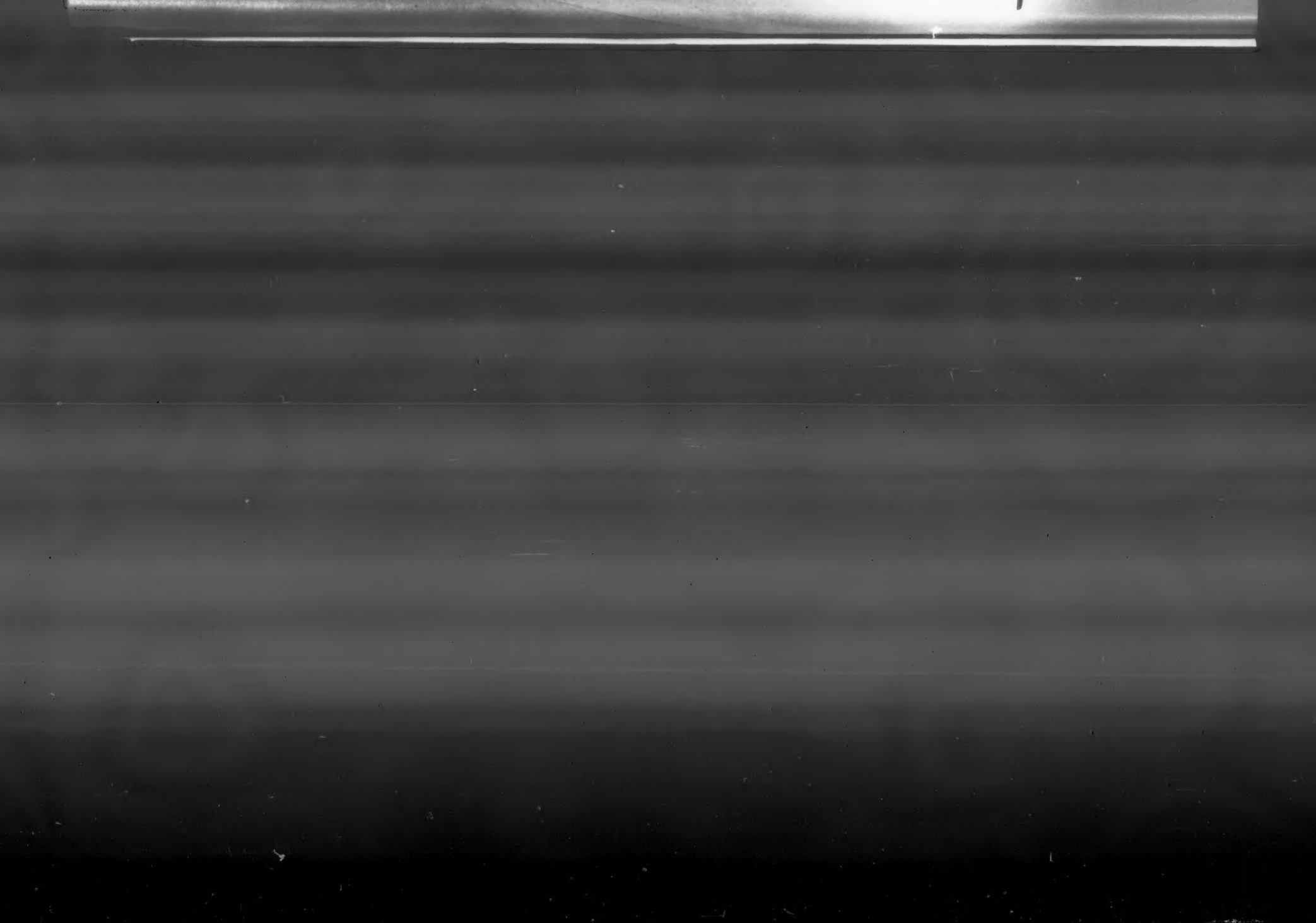

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U. S. Army Air Corps:

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Very truly yours,

C. C. MOSELEY, Pres.

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And, KEEPING PACE — Even Showing The Way — Are

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Introduction

By HON. ROBERT A. LOVETT

Assistant Secretary of War [Air]

THE establishment of the United States Army Air Forces will in time be regarded, I believe, as one of the real milestones in the march of American Aviation toward the goal of air power. Its establishment is the result of impartial and careful study of the lessons of European use of aircraft under combat conditions. It represents, furthermore, an effort to develop air power in such a way as to permit it to function smoothly under our existing Governmental procedure and to cooperate easily and effectively with the War and Navy Departments at all times. The Army Air Forces now have a degree of autonomy which has long been considered necessary. For the first time since its organization the destiny of the Air Forces lies largely in its own hands. America can have just as good an air force as it wants. We think the people want the best. That is what we are going to try to give them.

Robert A. Lovett

Why an AIR FORCE?

Strength in the air, as well as on land and sea, is vital to our mode of living and safeguarding its future.

by Col.
ROBERT OLDS

Born June 15, 1896, in Maryland, Colonel Olds holds D.F.C., and command pilot and corps observer ratings. He entered military aviation in 1917. A tactical expert, he is veteran of famous Air Corps flights.

WAR is organized force. The bewildering complexity of modern armies, navies and air forces simmers down to its elemental explanation in the national, and even hemispheric, use of physical force. We are not concerned with why the force is used, that being the realm of national policy. We are, however, every one of us, directly concerned with how it is used and why an air force has come to be the dominating feature in it.

Man, as a creature, is woefully weak. He has only his two fists, and a brain. His arms are short, and tire easily. Prehistoric man, in combat with great sharp-fanged animals, used his brain to provide himself with a club which compensated somewhat for his own physical shortcomings. The club was an extension of his arm—the beginnings of organized force.

Somewhat later he evolved a bow and arrow. The arrow was a longer extension of his arm, effective at 50 feet or more. A rifle is merely an elaborate extension of a man's hitting power. An army is an organized unit which represents a nation's combined hitting power.

We live and function in three mediums: land, sea and air. In each of these mediums we must be prepared to defend ourselves against attack, and to reply with energetic, aggressive attacks of our own. Until the start of this war, military operations in each of these elements were separated. The armies fought on land, the navies fought at sea, and in the world war (which saw the beginning of air power), aerial operations were merely short-range blows directed by army and navy chiefs.

Since that time air power has grown up. It has developed to such a stature that nobody knows quite how to exploit its prodigious strength to the utmost. It stands revealed now as a sort of Frankenstein monster; stronger than anything else, existing as a threat both to our enemies and to our own nation, which created it. Proper use of this giant's power demands proper strategic and tactical employment of the organized force which he represents. That is what the United States is trying to learn—fast.

We have the lessons of the past 20 years to guide us. We have, also, some pertinent lessons from other parts of the world within the last two years. U. S. observers are everywhere; in Europe, in the orient, in the middle east and in the south seas. Fact by fact we are accumulating the story of how air power is being used. In Washington, the Army authorities try to translate that story into quick action in the field. Ceaseless maneuvers, being held simultaneously in many parts of the country, show the Army how to adapt other nations' experience to our own problem.

Factually, our problem is defense. It is defense on a scale never before visualized. It involves protecting 21 nations beside our own; patrolling over 15,000 miles of coastline, two oceans, several seas and drawing an impenetrable ring of steel around entire western hemisphere.

In this gigantic effort, army, navy and air power jointly constitute the force to be used. While the United States maintains its air power under the dual control of Army and Navy, the general term *air power* is indivisible. It will be used by the Army and Navy, and at other times it will be combined into a striking force charged with executing independent missions of its own.

We need that versatility. Air power is everywhere at once—and nowhere. It is a many-armed force which can, simultaneously, screen naval operations afloat, support a mechanized column ashore and strike at distant enemy bases on independent missions of its own. Because of its mobility, air power can be assembled into an overwhelming strength at a local point for local operations, as the British used it at Dunkirk to keep the *luftwaffe* back and cover the historic embarkation of the BEF. When that mission is complete, air power can scatter across thousands of miles, not exposing itself to concentrated retaliatory attack by the enemy as must a slower striking force on land or sea.

We need the world's strongest air power because we are defending the richest area of the world against the greatest military power in history. That power knows the true value of coordinated air power; today it has the strongest air force in existence. Ours must be stronger. We must beat it in numbers, in replacements, in performance of individual types, in the excellence of our trained crews. The whole situation has reached a showdown. We are confronted with this superb foreign air power. A second-rate air force is worse than useless. It must be better—bigger, faster, harder-hitting and effective at greater ranges.

As rapidly as the country can stand the financial and industrial drain, we are collecting and training that kind of a force. It is not the best in the world yet—today it might be beaten in any test of strength. Tomorrow it may be able to seize and hold local superiority so that the land and sea forces may carry out local operations safely. Some day it can hold continental superiority, confining its enemy to other sections of the hemisphere. But the air force will never justify its cost until it can demonstrate, in battle, complete hemispheric success.

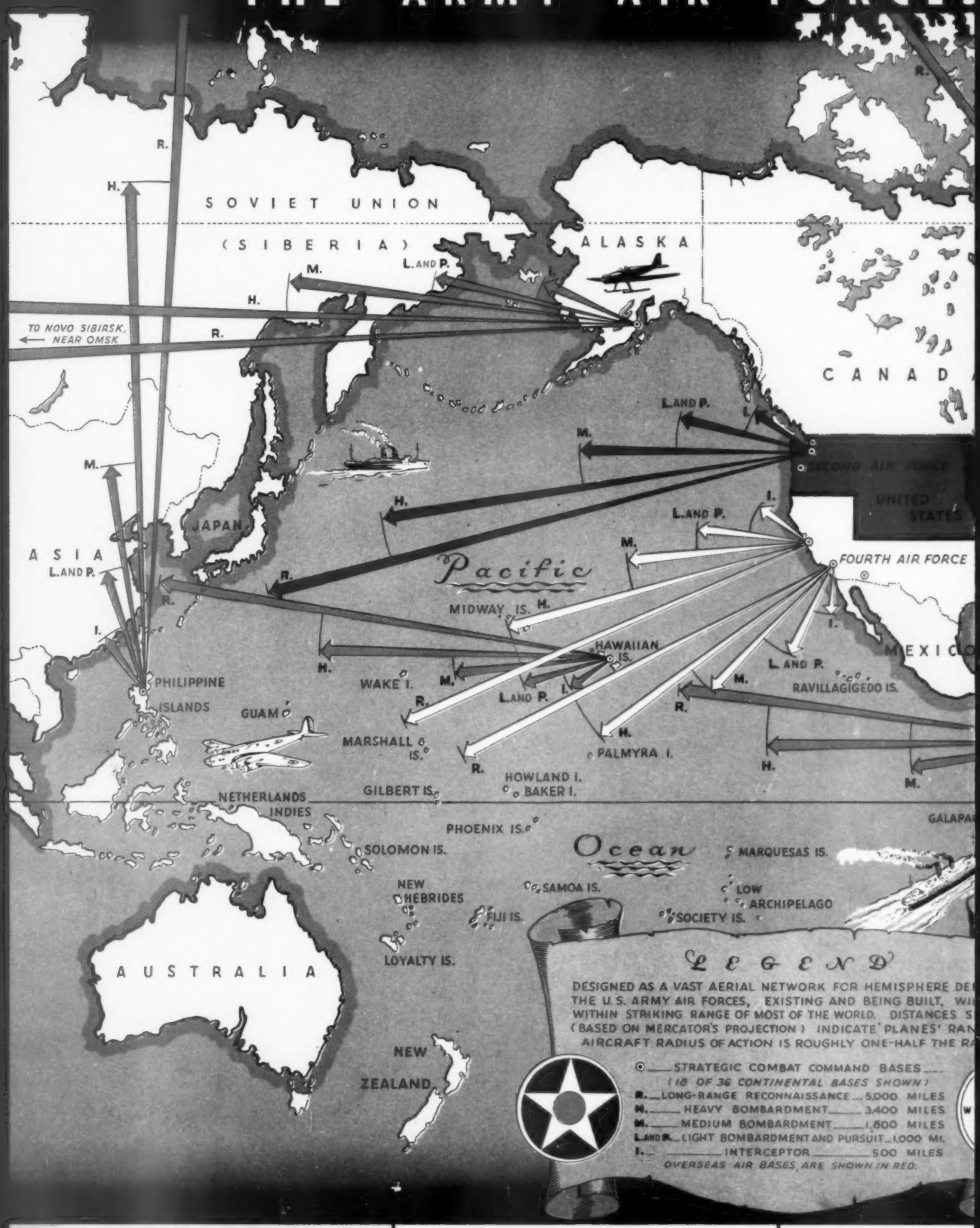
Air power can hold sea power helpless. That is not a claim that air power can defeat sea power, or that airplanes can sink battleships. But in one campaign after another, air power has shown its ability to hold powerful naval strength inoperative, divert it from its objective and keep it bottled up in bases. Britain's Mediterranean Fleet kept some of Italy's navy in a protective harbor at Taranto; some Fleet Air Arm Fairey *Swordfish* torpedo planes boldly attacked the anchored vessels and created appalling damage. Obsolete Blackburn *Roc* shipboard fighters on the *Illustrious* raided Tripoli, Massaua and other Italian harbors in Africa and filled them with sunken wrecks.

Germany's powerful pocket battleships *Scharnhorst* and *Gneisenau* are battered hulks in Brest harbor now; blasted night after night by RAF bombers. They cannot join the Atlantic showdown along Britain's lifeline. Air power, while not credited with sinking them, is holding them helpless. Germany has another superdreadnaught ready for commissioning; the *Tirpitz*. It would have joined the *Bismarck* in the Atlantic by now if the *Bismarck* had not fallen afoul of the same sinister force—Britain's air power.

(*Continued on page* 39)

The Tail of the B-19
by Lawrence Kronquist

THE ARMY AIR FORCES



LEGEND

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THE U.S. ARMY AIR FORCES, EXISTING AND BEING BUILT, WI
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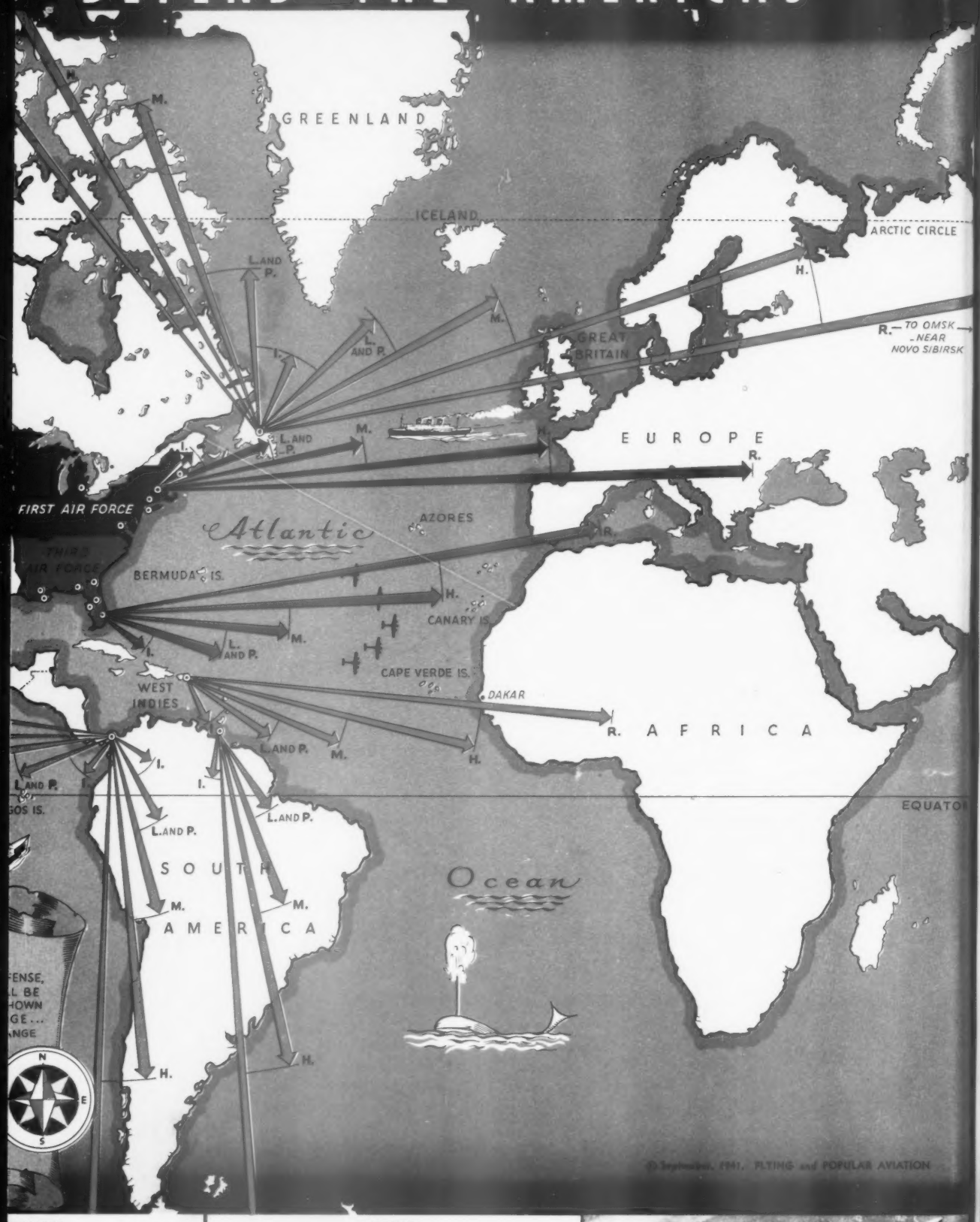
AIRCRAFT RADIUS OF ACTION IS ROUGHLY ONE-HALF THE RA

- ⊙ — STRATEGIC COMBAT COMMAND BASES — (18 OF 36 CONTINENTAL BASES SHOWN)
- R. — LONG-RANGE RECONNAISSANCE — 5,000 MILES
- H. — HEAVY BOMBARDMENT — 3,400 MILES
- M. — MEDIUM BOMBARDMENT — 1,600 MILES
- L. AND P. — LIGHT BOMBARDMENT AND PURSUIT — 1,000 MI.
- I. — INTERCEPTOR — 500 MILES

OVERSEAS AIR BASES ARE SHOWN IN RED.

DEFEND THE AMERICAS



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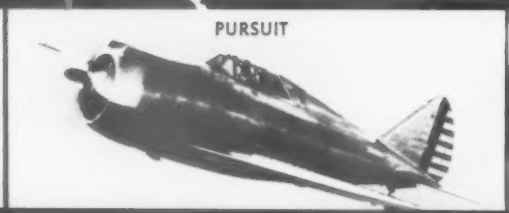

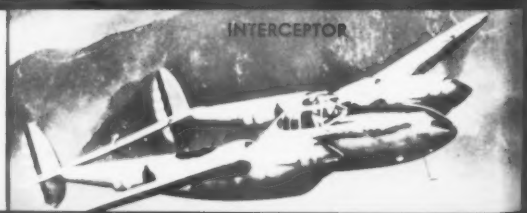

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The *Bismarck* landed a shell in the magazines of HMS *Hood* at the astounding range of 26,000 yards, and sank Britain's biggest warship. The British lost in the duel of big guns and battleships. But they won with air power. The same old *Swordfish* biplanes, operating from the *Ark Royal*, torpedoed the *Bismarck* four times, disabled her steering apparatus and caused the huge ship to swing around in wild, uncontrolled circles so that a mere cruiser could finish her off. After having escaped from the Royal Navy, the *Bismarck* was located again by a long-range U. S.-built flying boat.

That is an example of air power neutralizing sea power. It does not prove the superiority of one over the other, but it does answer for all time the argument about which is more powerful. The answer is that they belong together. Naval power plus air power is sea power. Ashore, an army plus air power is military power. Neither Army nor Navy can operate without air support. And an air force must have surface help to exert its power.

They are three of a kind and they belong to each other. Throughout southern U. S., the Army has been maneuvering recently on a large scale. There, for the first time, ever advancing mechanized column had its air support; A-20A's, obsolescent A-17A's, slow B-18A's, which did not appear to very good advantage in the opinion of official observers, but which showed the staff how far the road to air power lies before us. Those maneuvers told the Army that it is on the right path. But there is such a long way to go.

Reports from U. S. observers abroad said that in the Polish campaign (where the terrain was very similar to that in the south) every German panzer division; every mechanized column; every little tank patrol had its *Stukas* and Heinkels in support. In the Battle of France, German bombers were assigned to the artillery and laid down a bomb barrage ahead of advancing troops in lieu of artillery, which could not be moved up into position fast enough. Our staff knows that the *Luftwaffe* is a holding organization—a training and storage reservoir for all German air strength. From it, squadrons or individual planes are assigned to intensely close support of ground units. That liaison is perfected to a much greater degree than we have been able to perfect it here. German airplanes work so smoothly with ground forces that it is really a classroom demonstration in perfect staff work. Yet the *Luftwaffe* is an independent air force. That shows that it is not so much the organization of the air force, but how the organization is used, that counts.

The *Luftwaffe* has seven independent air forces and more than a million officers and men. We have four such forces and about 180,000 officers and men in our Army Air Force organization. By the time our airplane construction and training program is complete, we will have an Army air force about half the size of the *Luftwaffe*. Where we go from there depends upon the size of the *Luftwaffe* when the program is completed.

We must have an air force which is strong enough to force an enemy to fight hard to complete a single operation. It must be able to sweep the sky clean of enemy aviation and allow our own far-flying, hard-hitting bombers to get through to their distant enemy targets.

We need an air force so strong that it can accompany and support *all* the ground units engaged in *all* theaters of war at once. There must be no excuse for a U. S. debacle caused by enemy dive-bombers. There must be no bombed U. S. cities; no refugee-choked U. S. roads; no beaten and disheartened U. S. Army which had the will to fight smashed out of it by lack of air support. There must be no cry like that of the valiant Australians in Crete: *"Where are our airplanes!"*

We shall have them. We must have them. They stand between this hemisphere and eventual disaster.

END

In Appreciation

¶ It is with a great deal of pride that FLYING AND POPULAR AVIATION presents this special issue telling in detail the story of the United States Army Air Forces. FLYING AND POPULAR AVIATION, as one of the old and leading publications in the aviation field, feels that at this time the country wants a clear presentation of the Army Air structure and activities so that an intelligent view might be had by all of this great new Arm of Defense.

¶ We have been five months in the preparation of this issue in which leading officers have at our request given a graphic description of the principal activities which go to make up this great Air Arm.

¶ In the rapidly changing situation which exists in reference to our Defense Forces, it is impossible to keep the picture absolutely up-to-date. There have been changes since this material was prepared. Undoubtedly considerable changes will have materialized before this issue is very old.

¶ We trust, as we believe, that this edition of FLYING AND POPULAR AVIATION will serve a useful purpose in acquainting Americans with the physical structure of their Army Air Forces.

William B. Ziff

Publisher

HISTORY of the AIR

by MARGUERITE JACOBS HERON

Since 1917 at McCook Field, Mrs. Heron has been associated with the Air Corps in public relations. She has written many articles and books on military aviation. She is stationed at Army's Wright Field.

THE history of the Army Air Forces is that of a lusty baby which became successively a problem child, an adolescent orphan and presently a giant adult who dwarfed the rest of the family. The relationship between the Army and the Air Forces is hardly that of the Navy and its Marines. It is like that of a father whose son grows so big that he can no longer be spanked with safety and who must finally be treated as a partner.

The Air Forces' organized history is a matter of weeks. Some of its details are not completely understood yet. What has been done to the old Air Corps and GHQ Air Force is still a matter of debate among ranking officers and hence the final paragraph in the history of our air arm cannot be written to bring it up to date.

Its beginnings, however, are well-recorded and thoroughly cross-indexed in military histories. Our country pioneered the entire policy of aerial warfare. In the United States the airplane first flew; the inventors sold the first military plane to the parent Government and demonstrated it at the world's first military air field. We had an Army air unit and the beginnings of a Navy unit before any other world power showed interest in the idea. Then, as with so many other things, we became involved in discussions about it and did not notice that other nations had far outstripped us in practical application of our original idea.

During the Civil War there were some spectacular sorties by balloons which are supposed to mark the beginnings of our military air arm. They had no more practical value than the use of balloons by besieged Parisians in 1871. In 1890 the Army purchased a reconnaissance balloon from France and used it in the Spanish-American War. It was not a great success.

For three-and-a-half years after the practical demonstration of the airplane, the Army watched it without any expression of interest. On July 1, 1907, it was decided to establish an aeronautical section in the Signal Corps and to purchase an airplane for experimental purposes. Out of many proposals received, including those of a Mr. Scott of Chicago ($1,000); A. H. Herring of New York ($20,000) and the Wright brothers, Dayton, O. ($25,000); only the Wright brothers could meet the necessary conditions and were given the contract. Their plane was delivered at Ft. Myer, Va., on Aug. 28, 1908, where several test flights were made. In September, 1908, Orville Wright remained in the air for one hour and two minutes with Lieut. G. C. Sweet, the Navy's official witness, timing him with a stop watch.

During this period, aviation suffered its first serious crash. While on a trial flight, the plane made a crash landing and killed Lieut. Thomas Selfridge, an artillery officer, and seriously injured Orville Wright, who has done very little flying since.

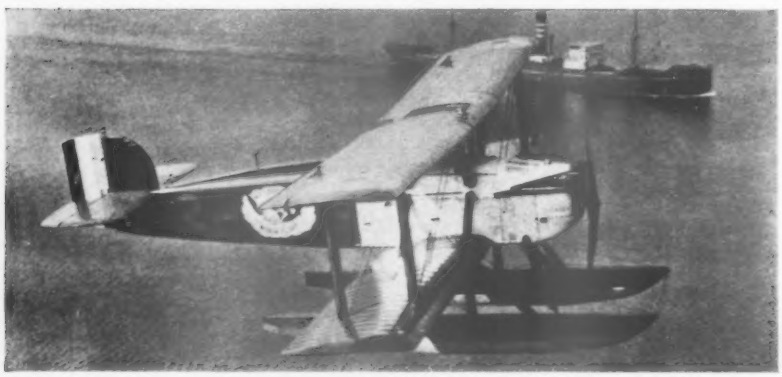
While the Wrights were rebuilding their plane and their reputation, aviation arrived in the armies of Europe. The first airplane in Germany was a military plane, flown in 1909. In August of that year, the Chief Signal Officer, U. S. Army, Brig. Gen. James Allen, approved the findings of a board of officers and recommended that the U. S. purchase another Wright plane.

When delivered, it was assigned to the Signal Corps and used infrequently for observation during field maneuvers. This was the ship that was launched by a weight falling from a tower; which had no landing wheels and landed on wooden skids; and which demanded the greatest skill from its pilot in maintaining balance, since it had no ailerons and demanded much leaning and twisting on the pilot's part to warp the wings by means of a shoulder harness. In 1911 an old Cadillac car which had been used by General Allen was assigned to the aviation section to carry cans of gasoline and ferry the mechanics back and forth between Washington and Ft. Myer. Until 1913 this was the air arm's entire transport.

The plane flown by this crew cost the Government $30,000, of which $5,000 was a bonus for exceeding specifications. It had a 25 h.p. motor built by the Wrights in their own shop, turning two eight-and-a-half-foot propellers driven by bicycle sprockets and chains. It had a top speed of 40 m.p.h. and a cruising range of 125 miles. Its greatest asset was that it could be disassembled and shipped along with the Army in a truck.

Lieut. Frank P. Lahm, Lieut. Frederick E. Humphries, Lieut. Benjamin Foulois, Lieut. H. H. Arnold and other future high-ranking Air Corps commanders were among the early pupils

This Douglas Air Cruiser, the "Chicago," flown by Lieut. Leslie P. Arnold, was one of the planes that participated in the first round-the-world flight in 1924.



Route followed by Lieutenant Arnold and five Army flyers on their famous flight.

FORCES

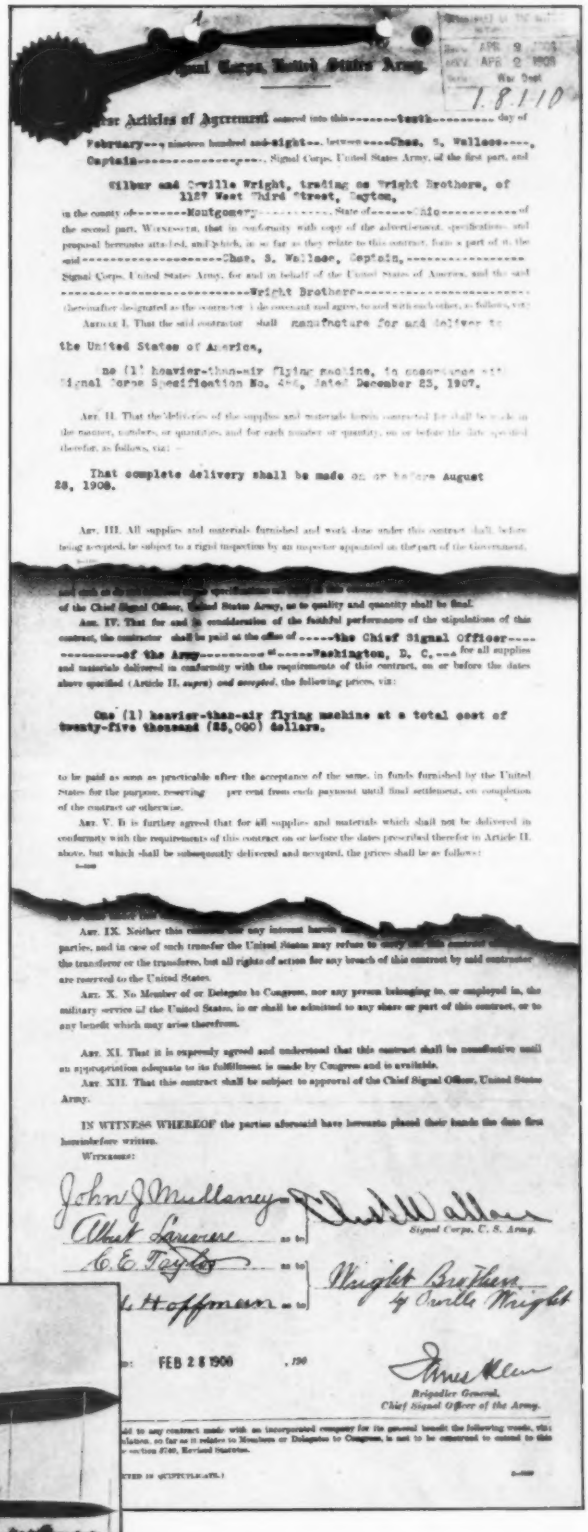
World aviation grew up with the Army's air force. This is the story of a 32-year-old earth-shaking giant.

of the Wrights, both at Ft. Myer and later at a bigger field at College Park, Md., Lieutenant Lahm learned to fly and became the Army's first instructor. His first student, oddly enough, was a Navy officer—Lieut. G. C. Sweet, who had timed Orville Wright's first military flight. In 1910 the infant air arm had three officers, nine enlisted men, one Wright pusher airplane and three balloons.

The following year, Congress appropriated $125,000 for three more planes, of which the Wrights furnished two and Glenn Curtiss one. In 1911 there were five planes, six flying officers and one obsolete automobile. Among the officers receiving instruction at this time were Lieut. H. H. Arnold (at College Park and Dayton); Lieut. Thomas De W. Milling; Capt. Paul W. Beck; and Lieuts. John C. Walker and C. E. Kelly, the latter four assigned to the Curtiss school at San Diego, Cal.

At the outbreak of the European war in the summer of 1914, Germany was reported officially to be operating 1,000 airplanes, among them the Taube 150 m.p.h. monoplane, the first Fokker biplane and others. On July 1 of that year the U. S. owned eight airplanes and had organized one squadron, comprising 16 officers and 77 enlisted men. Some of these planes were first used in tactical service during the Villa punitive expedition in 1916 and turned out to be disappointing. They could not stay in the air long enough to be of any great value and they required expensive protection from bandit raids against the fields where they were set up. The Army's first aerial bomb dates from this campaign, when an airman dropped a crude home-made affair over the edge of his lower wing and saw it explode in a bandit camp.

This was in 1916, when Rene Fonck was scoring dozens of aerial victories with Nieuports; when Baron Manfred von Richtofen had pioneered attack formation techniques in Fokker D-VII's and when the Immelmann and the Lufberry Circle were daily occurrences over the western front. Those airplanes were far ahead of the crude U. S. pushers. Throughout the war, the United States never caught up with Europe in airplane design. The sum of $13,281,666 was appropriated for aeronautical development at the time the U. S. entered the war. Part of this sum was used to establish McCook Field, near Dayton, as an aeronautical research center.



Articles of Agreement entered into this ---tenth--- day of February---, nineteen hundred and eight---, between ---Chas. S. Wallace---, Captain---, Signal Corps, United States Army, of the first part, and

Wilbur and Orville Wright, trading as Wright Brothers, of 1127 West Third Street, Dayton, in the county of ---Montgomery--- State of ---Ohio--- of the second part, WITNESSETH, that in conformity with copy of the advertisement, specifications, and proposal hereunto attached, and which, in so far as they relate to this contract, form a part of it, the said ---Chas. S. Wallace, Captain, Signal Corps, United States Army, for and in behalf of the United States of America, and the said ---Wright Brothers--- hereinafter designated as the contractor, do covenant and agree, to and with each other, as follows, viz:

ARTICLE I. That the said contractor shall manufacture for and deliver to the United States of America,

one (1) heavier-than-air flying machine, in accordance with Signal Corps Specification No. 486, dated December 23, 1907.

ART. II. That the deliveries of the supplies and materials herein contracted for shall be made in the manner, numbers, or quantities, and for each number or quantity, on or before the date specified thereto, as follows, viz: —

That complete delivery shall be made on or before August 28, 1908.

ART. III. All supplies and materials furnished and work done under this contract shall, before being accepted, be subject to a rigid inspection by an inspector appointed on the part of the Government, and such as do not fulfill the specifications [illegible] of the Chief Signal Officer, United States Army, as to quality and quantity shall be final.

ART. IV. That for and in consideration of the faithful performance of the stipulations of this contract, the contractor shall be paid at the office of ---the Chief Signal Officer--- ---of the Army--- ---Washington, D. C.--- for all supplies and materials delivered in conformity with the requirements of this contract, on or before the dates above specified (Article II, *supra*) *and accepted*, the following prices, viz:

One (1) heavier-than-air flying machine at a total cost of twenty-five thousand ($25,000) dollars.

to be paid as soon as practicable after the acceptance of the same, in funds furnished by the United States for the purpose, reserving per cent from each payment until final settlement, on completion of the contract or otherwise.

ART. V. It is further agreed that for all supplies and materials which shall not be delivered in conformity with the requirements of this contract on or before the dates prescribed therefor in Article II. above, but which shall be subsequently delivered and accepted, the prices shall be as follows:

[illegible] ART. IX. Neither this contract nor any interest herein [illegible] parties, and in case of such transfer the United States may refuse to carry out this contract [illegible] the transferor or the transferee, but all rights of action for any breach of this contract by said contractor are reserved to the United States.

ART. X. No Member of or Delegate to Congress, nor any person belonging to, or employed in, the military service of the United States, is or shall be admitted to any share or part of this contract, or to any benefit which may arise therefrom.

ART. XI. That it is expressly agreed and understood that this contract shall be nonoperative until an appropriation adequate to its fulfillment is made by Congress and is available.

ART. XII. That this contract shall be subject to approval of the Chief Signal Officer, United States Army.

IN WITNESS WHEREOF the parties aforesaid have hereunto placed their hands the date first hereinbefore written.

Witnesses:

John J. Mullaney — Chas. S. Wallace, Signal Corps, U. S. Army.
Albert Lawrence — as to
C. E. Taylor — as to
[illegible] Hoffmeyer — as to
Wright Brothers, by Orville Wright

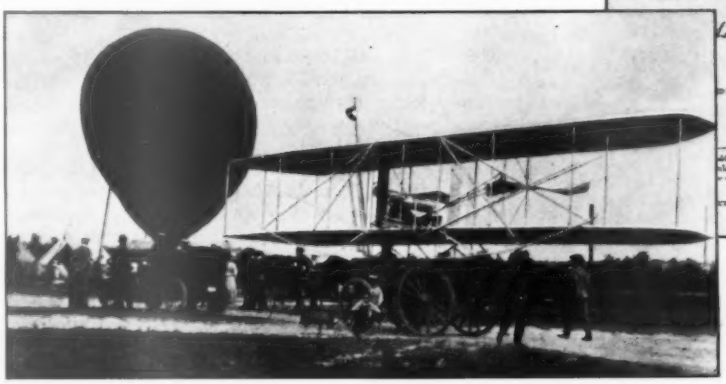
Approved: FEB 28 1908, 190

James Allen, Brigadier General, Chief Signal Officer of the Army.

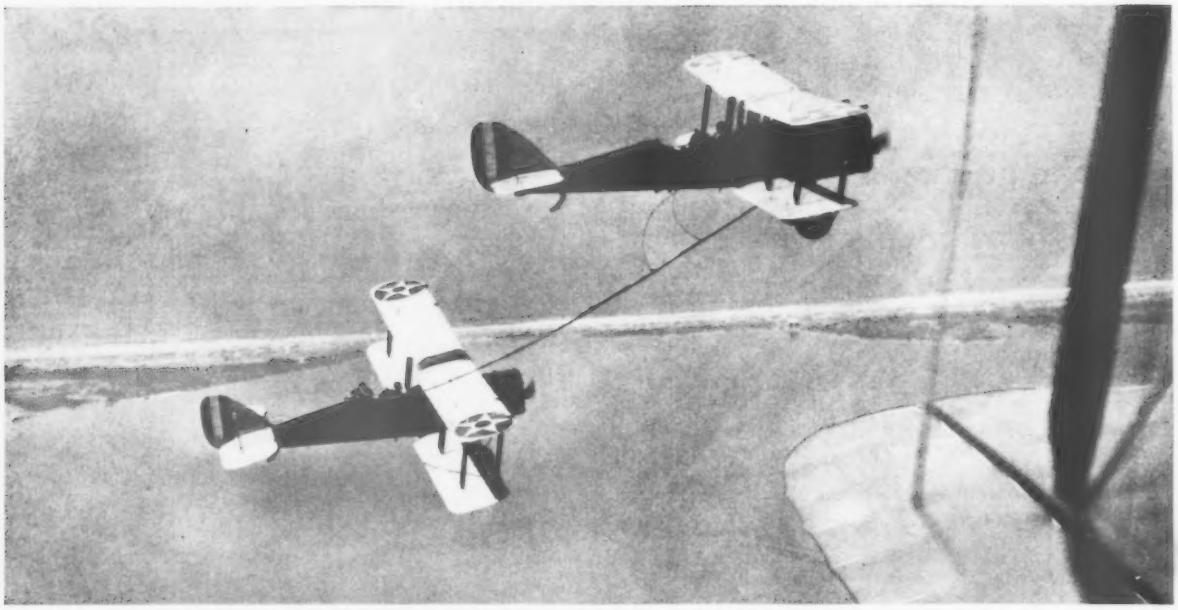
[illegible] to any contract made with an incorporated company for its general benefit the following words, viz: [illegible] relation, so far as it relates to Members or Delegates to Congress, is not to be construed to extend to this [illegible] section 3741, Revised Statutes.

[illegible] ENTERED IN DUPLICATE.

Wilbur and Orville Wright, aided by their sister, raised $10,000 "guarantee fund" before starting work on Army's plane. Contract (above) required this from all bidders. Two couldn't raise money.



Specifications required that the first Army airplane could be dismantled without trouble and carried on ordinary wagon.



The Army introduced this method of refueling in mid-air with these two World War De Havillands. Later, with the Fokker trimotor "Question Mark", Army flyers set 150-hour endurance flight record.

At the outbreak of America's participation in the war we had 55 airplanes, all obsolete; 65 officers in the Aviation Section of the Signal Corps, of whom 35 were pilots; and 1,087 enlisted men. No U. S. airplane had machine guns, although French Nieuports were mounting two belt-fed fixed guns at the time and Georges Guynemer scored his 37th aerial victory in a Spad XIII with a 37 mm. aerial cannon in 1916. During the entire period from the invention of the airplane to 1917, the U. S. had purchased only 142 planes, while England had 250 fighters in commission in 1914 and France had about 300. Our airplane industry in the U. S. was geared to a production of 12 to 15 planes per year—all pushers without fuselages.

From this inauspicious beginning, the war forced the country to undertake an annual production of 10,000 planes for our own air unit and 16,500 more for the French by midsummer of 1918. None of the production planes built here for combat use were U. S. designs. We built the DH-4 observation, the Handley-Page bomber, the SE-5 pursuit and were endeavoring to get a Spad for engineers' study when the Armistice intervened. America's major contribution to aerial warfare, 1914-18, was the magnificent Liberty engine, admittedly the world's best aircraft power plant at the time. Some U. S. combat designs, including the Martin twin-engined bomber, the Thomas-Morse scout, with its Le Rhone rotary engine, and the Navy's F5L seaplane patrol bomber, were completed and put into production too late for service over the western front. In our training schedule there was a similar disappointment. None of the pilots trained in this country could be assigned to tactical service. All of them had to receive advanced training abroad.

In 1925 Jimmy Doolittle (below), flying in this Curtiss-built seaplane racer, set record in winning Curtiss-Schneider Race.

Notwithstanding the necessity for foreign training, flying European-built planes and serving in French, English and Italian squadrons, the Aviation Section of the Signal Corps turned in an impressive war record. In March, 1918, it had 757 pilots, 498 observers, 750 airplanes and 77 balloons in service with front-line squadrons. Hundreds more were detached for duty with other Allied commands. During the war U. S. airmen shot down a total of 491 enemy airplanes, of which 462 were accounted for by 63 airmen. We had 43 squadrons at the front at the time of the Armistice, but of these, less than 25 per cent had U. S.-built planes and those were all DH's, with a few Martin bombers.

As suddenly as the aviation industry had been forced into being, it collapsed. Aviation activities were withdrawn from the Signal Corps in 1918 to simplify command and placed under a new combat branch, the Air Service. Demobilization of the country after the war left the infant air arm with only 1,000 officers and 10,000 enlisted men from its wartime peak of 18,000 officers and 135,000 enlisted men.

Unable to wield much influence in Army decisions, the new Air Service went in heavily for records—new performance marks in every phase of flying. On Feb. 27, 1920, before wartime demobilization was complete, Maj. Rudolph W. Schroeder (now vice president of United Air Lines) established a world's altitude record of 33,000 feet. About a year later, on Feb. 12, 1921, the Army Air Service opened the first organized airway, from Washington, D. C., to Dayton, O.

That was the era of Gen. "Billy" Mitchell and his demand for complete separation of the air force, publicized by test bombings of condemned battleships off the Virginia capes in 1921. On the first test, a Martin bomber dropped a 2,000-pound bomb on the obsolete battleship *Alabama*, sinking it rapidly

Inside the gondola of "Explorer II," Lieut. Col. A. W. Stevens and Capt. Orvil A. Anderson recorded valuable data ascending to 73,395 ft. for world's record.

Maj. Rudolph Schroeder, who set world's altitude record of 33,000 ft. in 1920.

although it did not strike the ship's deck but exploded in the sea alongside.

Between 1920 and 1935 only slight modifications were made in the World War system of air tactics, one of them being the introduction of attack aviation about 1924. In 1923, Lieuts. John A. Macready and Oakley G. Kelly flew the Fokker T-2 transport plane non-stop across the United States in one day; in the same year a flight of Douglas *Cruisers* carried the U. S. Army Air Service emblem around the world. During 1924, Lieut. George W. Goddard made the first successful night aerial photograph, which forced major changes in air force tactics throughout the world. Just after the Lindbergh flight in 1927, Lieut. Albert F. Hegenberger and Lieut. Lester J. Maitland accomplished the first crossing of the Pacific from California to Hawaii in the Fokker transport *Bird of Paradise.*

The year 1927 was a record-breaking one for aviation in general. For the Air Corps it marked the beginnings of endurance and refuelling flights. It saw the successful completion of a 20,000-mile good-will visit by air throughout South America, the formation returning to Washington on May 2, 1927, after an absence of five months. On the same day Capt. Hawthorne G. Gray was found mysteriously dead in the basket of a free-flight balloon after having reached an altitude of 42,470 feet, the highest altitude then reached by man. On June 30, 1928, Capt. William E. Kepner and Lieut. William O. Eareckson, his aide, won permanent possession of the Gordon Bennett Trophy for the Air Corps, adding to America's prestige in the balloon world.

Throughout the ensuing decade the Air Corps continued to add to its collection of world performance records. On Aug. 31, 1929, Capt. Albert W. Stevens photographed Mt. Rainier from an airplane at a distance of 227 miles, exceeding by 50 miles all previous photographic distances. A few weeks later, on Sept. 24, 1929, Lieut. James H. Doolittle gave a public demonstration of instrument flying in which he accomplished a take-off and a landing by instruments alone, in a hooded cockpit.

In 1930 and 1931 attention veered from the purely spectacular to the future of the corps. On June 20 and 21, 1930, Randolph Field, near San Antonio, Tex., was dedicated as Air Corps training headquarters. In 1931, on May 18 to 30, the annual Air Corps field exercises began at Dayton, O., and ended at Washington. They covered the Atlantic seaboard from Maine to Virginia. The First Air Division comprised a personnel of 692 officers, 69 flying cadets and 643 enlisted men, all of whom participated. A total of 667 airplanes was used in this maneuver, largest in the corps' history.

In 1932, Capt. Albert F. Hegenberger accomplished the first blind flight, using instruments exclusively, on May 9. The following year, belated recognition came to Master Sgt. Ralph Bottriell of Kelly Field, Tex., when he was awarded the newly-authorized Distinguished Flying Cross for his aid in developing free-type parachutes in 1919. As a result of Sgt. Bottriell's work, the Air Corps developed the present types of parachutes.

The year 1935 was a noteworthy one for the Air Corps, beginning on March 1 when the GHQ Air Force was officially organized. On August 29, 1935, the radio compass proved its merit when Air Corps engineers made the first flight wherein radio navigation by automatic pilot was accomplished. On Nov. 11, Armistice Day, 1935, the historic stratosphere flight of Capts. A. W. Stevens and Orval A. Anderson took

Lieuts. Albert F. Hegenberger (left) and Lester J. Maitland in 1927 flew from California to Hawaii in "Bird of Paradise."

THIRTY-TWO YEARS OF MILITARY AIRCRAFT PROGRESS

This 1909 military "aeroplane" was launched by weighted pulleys.

American-built World War plane was this DeHavilland DH-4.

The Keystone LB-7, one of the first multi-engined bombers.

The four-engined Consolidated B-24 is latest heavy bomber.

place and reached the all-time record altitude of 72,395 feet in a huge balloon.

Rescue missions appear in Air Corps records in 1936, flown by the Second Bombardment Group of Langley Field, Va., which dropped 8,000 pounds of food and medical supplies to Pennsylvania communities isolated by a disastrous flood. A total of 45 officers and 100 enlisted men, using 30 airplanes, flew these supplies in relays. In June, 1936, Maj. Gen. Frank M. Andrews established a new distance record for amphibians by piloting a Douglas OA-5 plane 1,425 miles from Puerto Rico to Langley Field, Va., in 11 hours and nine minutes.

Experiments in high-altitude oxygen equipment occupied the Materiel Division early in 1937, when the Lockheed XC-35 pressurized-cabin plane was delivered at Wright Field. On Aug. 5, 1937, it made its first flight, equipped with cabin oxygen which made face masks unnecessary. On Aug. 23 of the same year, Capts. Carl J. Crane and George V. Holloman, with Project Engineer Raymond K. Stout (a civilian), made two completely automatic landings under adverse weather conditions at Wright Field.

The first post-war change in command tactics came in 1935, when the GHQ Air Force was set up by Maj. Gen. Oscar Westover, Chief of Air Corps, and assigned to the command of Col. Frank M. Andrews, who thereupon was promoted to the grade of major general. The present Air Forces is an outgrowth of command experience accumulated by General Andrews between 1935 and 1940, when he was named to the General Staff in command of all Army operations and was succeeded by Maj. Gen. Delos C. Emmons. Late in 1940, General Andrews was reassigned to the Air Forces and detailed as commanding general, Caribbean Air Force. General Emmons attained the rank of lieutenant general, co-equal in rank with the commanders of the four field armies, and was named Chief of the Combat Command of the Army Air Forces in the recent reorganization. Coordinated under his command are four continental Air Force districts, composed of fighting air organizations.

At present, the Army Air Forces consists of the Combat Command and its tactical organizations; the Air Corps with its training, supply, procurement and research functions; and the Headquarters Air Force, which is the general staff section of the air arm. Activated today are 17 combat wings, totaling 54 groups, with a goal of 22 combat wings in sight. Unified command has been achieved in the person of Maj. Gen. H. H. Arnold, Chief of the Army Air Forces, who is in direct control of the entire organization.

From its inception during the World War, when it was separated from the Signal Corps, the air arm has seen only six changes of command. Its first chief was the venerable Maj. Gen. Mason M. Patrick, an able engineer officer who was detailed by General Pershing as Chief of the AEF Air Service in May, 1918. In June, 1919, he was confirmed by Congress as Chief of Air Service for a four-year term and was reappointed in October, 1925. He held the post until his retirement on Dec. 13, 1927. General Patrick was succeeded by Maj. Gen. James E. Fechet, who held command from Dec. 14, 1927, to Dec. 19, 1931. The first veteran airman to hold the supreme air command was Maj. Gen. Benjamin D. Foulois, one of the Wright brothers' first students, who served from Dec. 20, 1931, until Dec. 21, 1935. He was succeeded by the late Maj. Gen. Oscar Westover, under whose command the GHQ Air Force was introduced. General Westover was Chief of Air Corps from Dec. 22, 1935, until Sept. 21, 1938. He, in turn, was succeeded by Maj. Gen. H. H. Arnold, who was Chief of Air Corps from Sept. 22, 1938, until May 23, 1941, when he became Chief of the Army Air Services. The present Chief of Air Corps, a subordinate post in the larger Air Forces organization, is Maj. Gen. George H. Brett, who for many years was a brigadier general and Assistant Chief of Air Corps and Chief of the Materiel Division.

But the man who started all this—Orville Wright, to whom military aviation is indebted for its first airplane—sits calmly by and watches his brain child grow to phenomenal proportions. He seldom will talk for publication, but on one occasion recently when he was helping to dedicate a new engine plant in Cincinnati he said:

"We little dreamed that the airplane would develop into a machine for destruction. We had hoped sincerely that our invention would help to do away with war by bringing the real horrors of it home to the very doorsteps of warring nations. We saw only that the airplane might be used for observation purposes, but did not intend that it should be used to destroy our fellow men."

END

COMBAT COMMAND

This organization is our air arm's striking force. Other air activities exist only to supplement its work.

by Lieut. Gen.
DELOS C. EMMONS

Today commanding general of the Combat Command, fighting organization of the Army Air Forces, General Emmons began aerial service in 1917 when, an infantry captain and West Point graduate, he transferred to the Aviation Section of the Signal Corps. He is 53 years old.

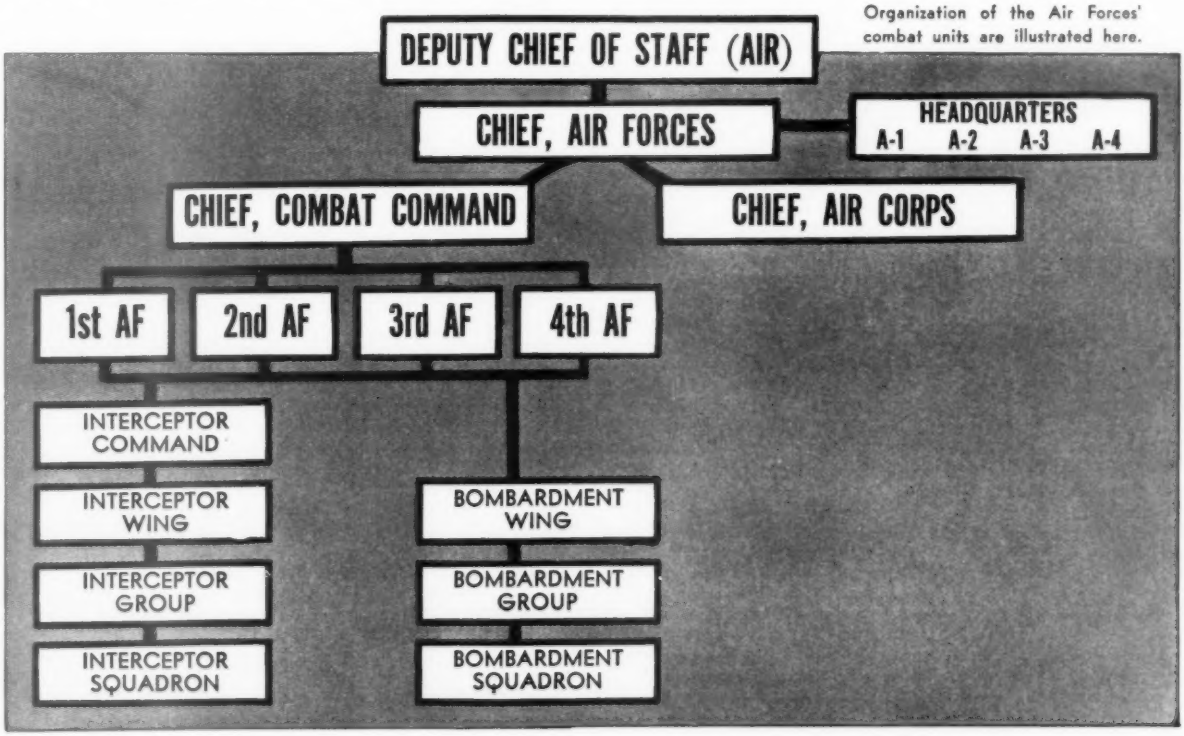
THE development of the Air Force Combat Command from its inception in 1935 will form an important part of the historical background when the epic of the part played by the United States in the second World War is written. Organized to meet the tactical need for a mobile striking force, the Combat Command came into being through the findings of the Drum Board, composed of outstanding general officers and the Chief of Air Corps, which made its report in 1933. Authorized by Congress a year later under its former designation, the General Headquarters Air Force, it was officially constituted Mar. 1, 1935, and placed in command of the then Brig. Gen. Frank M. Andrews. Events abroad during the last two years have borne out the wisdom and foresight of the Drum Board and Congress in creating this potentially powerful air armada.

The Air Force Combat Command might also claim collateral descent from the Independent Bombing Force created by the British in 1917 and from the Inter-Allied Independent Bombing Force which was in the process of organization when the first World War ended. The British Independent Bombing Force extended the scope of military aviation from the battle-front and immediate environs to include the industrial and mobilization centers far in the rear.

One of the first discoveries made under the new form of organization was the necessity for a new and uniform training program to insure proper coordination among the combat teams when the individual units were brought together. Although in the past all combat units had been trained under the same general directives, the results as to proficiency varied considerably, so that combat units from different stations were not able to work together smoothly. This deficiency was attacked at once, with the result that uniform training throughout the entire organization has been attained, making it possible for units which have never before operated together to fit smoothly into whatever air force team they may be assigned to and without further combined training.

Another accomplishment of this training program has been the shift in emphasis from the individual to the combat team, a goal which had been sought in the past but never attained in the airplane crew until the advent of the GHQ Air Force, which centralized the training of our tactical air units under

Organization of the Air Forces' combat units are illustrated here.



GENERALS OF THE COMBAT COMMAND

Lewis H. Brereton | John B. Brooks | Henry B. Clagett

Howard C. Davidson | Jacob E. Fickel | Walter H. Frank

Arnold N. Krogstad | Frank D. Lackland | Frederick L. Martin

Junius W. Jones | John C. McDonnell | Millard F. Harmon

William O. Ryan | Clarence L. Tinker | Carlyle H. Wash

Joseph T. McNarney | James E. Chaney | Herbert A. Dargue

one command. In this spirit of constant striving for improvement in training and tactical methods, the GHQ Air Force had shown steady improvement. This proficiency has been readily discernible in the three large scale exercises, the first in Florida in December, 1935, only a few months after its creation, the second in California in May, 1937, and the third in the northeastern part of the United States a year later.

The exercises were very carefully planned, taking advantage of lessons learned from aerial tactics practiced during the World War and various theoretical operations of military tacticians. Each of the exercises was carried out utilizing the full strength of the GHQ Air Forces and operating them under simulated wartime conditions. The results were studied by military authorities and many errors in tactical planning were discovered and corrected, bringing about many changes in the original established setup. The necessity for coordination of air force operations with ground forces was plainly demonstrated and every means possible was taken to bring about cooperation between the two.

Starting from its original complement of a few squadrons of nearly obsolescent planes, the newly designated Air Force Combat Command has developed rapidly into a compact, hard-striking force despite the wide geographic area over which it must of necessity be dispersed. By 1939, it had grown to 29 squadrons of all types, organized into three wings, with its headquarters at Langley Field, Va. The three wings corresponded roughly to the Atlantic, Central and Pacific sections of the country. The First Wing, with headquarters at March Field, Riverside, Cal., was composed of two groups of bombardment, one group of attack and two squadrons of reconnaissance planes. The Second Wing had headquarters at Langley Field and comprised two groups of bombardment, two groups of pursuit and two reconnaissance squadrons. Headquarters of the Third Wing was at Barksdale Field, Shreveport, La., to which two groups each of pursuit and attack planes were assigned.

A brief outline of the organization of this force only two years later will serve to illustrate its rapid growth due to the meteoric rise of air power in the world of today. The three wings have been increased to 17, the 10 groups to 42, the 29 squadrons to nearly 300. To secure better coordination the three geographic belts into which the country had been divided under the old setup were reformed into four areas, the Northeast, Northwest, Southeast and Southwest. Each of these were later designated as Air Forces.

The First Air Force, with headquarters at Mitchel Field, Long Island, N. Y., is composed of five wings: the Fourth Wing, a heavy bombardment unit, divided between Westover Field, Mass., and the Army Air Base at Bangor, Me.; the Second, consisting of medium and heavy bombardment at Langley Field; the Seventh, comprising interceptor pursuit Squadrons, divided between Mitchel Field and Windsor Locks, Conn.; the Sixth, fighter and interceptor units assigned to Selfridge Field, Mich., and Fort Wayne, Ind.; and the Sixteenth Wing, light bombardment, at Bowman Field, Ky., and Manchester, N. H.

The Second Air Force is composed of three wings and has its headquarters at Spokane, Wash. The Fifth Wing, light medium and heavy bombardment, is divided between Sunset

(*Continued on page* 188)

BOMBARDMENT

The bomber is the backbone of the air force. U.S. Army Air Forces bombers now are standardized in three classifications: heavy, medium and light.

Douglas B-18A's of the Ninth Bombardment Group.

BOMBARDMENT

by Lieut. Col. HAROLD L. GEORGE

Recently named to War Plans staff of the Air Forces, Lieutenant Colonel George is a veteran whose experience dates to 1917. Born in Massachusetts in 1893, he is a command pilot and corps observer.

LESS than 35 years ago the great newspapers and magazines of the world were ridiculing the efforts of a small group of unknown men who were devoting their entire effort to make flying in heavier-than-air machines an accomplished fact. Joining in this ridicule were men holding important and distinguished positions in Government and Industry.

In spite of this studied effort to discredit them before the eyes of the world, this "small group of unknown men" continued to concentrate their lives to the realization of their dream. They knew, deep down in their inner souls, that man would conquer the air as he had conquered steam, electricity, sanitation and all other problems which had created obstacles in the advance of civilization. The disbelievers were myriad. The doubting Thomases, because of their enviable positions in the world, made the task of these pioneers in aviation difficult beyond all imagination. Mankind is inclined to accept those inventions and developments, which he sees in his daily life, without realizing the penalties which the original men of vision had been called upon to pay in order that the world might be torn from its static state.

Finally, as it became evident that man could fly in a machine heavier-than-air, we find the same doubting Thomases maintaining that flying would never be of any consequence insofar as its effects upon civilization were concerned, because of its manifests limitations. Military and Naval men claimed that it would be of no value in warfare!

Today, less than 38 years since the Wright brothers made their first two-minute flight at Kitty Hawk, we find air power vitally changing the entire method of waging war. We see a great empire struggling for its very existence because of the ability of its enemy to strike at its very vitals through the medium of the air. We find armies and navies, as such, unable to cast their mantle of protection, as was possible before the development of air power, between their peoples and the forces of world gangsterism.

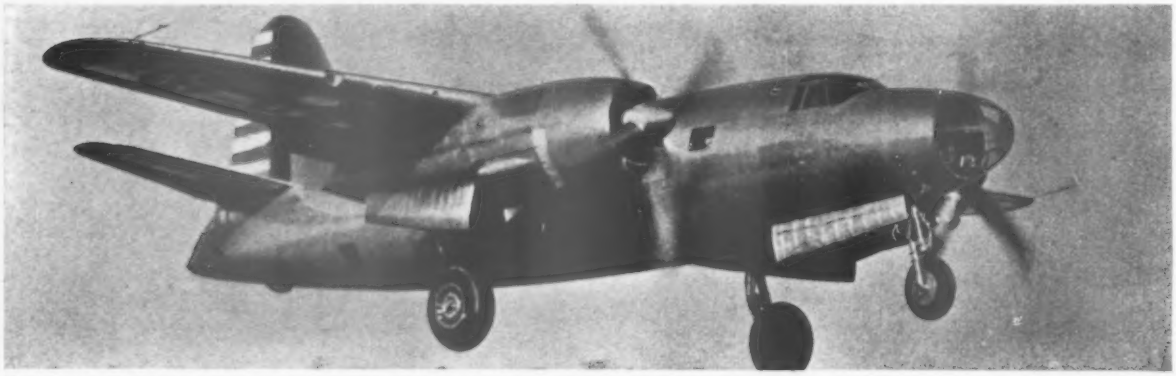
Air power is today threatening great nations because of its ability to strike directly at the means by which those nations are able to prosecute war. Our modern civilization is made possible because of an intricate system of industry and communications, without which we would revert to the colonial era. This system has created an involved and sensitive industrial and economic structure which, while making us strong in one sense, has made us weak in another. This apparent anomaly exists because industrial development has made necessary the creating of vast centers of population which are absolutely dependent upon other areas, far removed, for their daily existence. Vast quantities of foodstuffs and raw materials must be continually moving from the world's farm-lands and mining centers to feed the industrial machines and the workers who operate those great machines. The fabricated materials must daily move away from those centers to those places in the world where they, in turn, pass into the blood stream of industry and commerce which are the veins and arteries of our modern civilization.

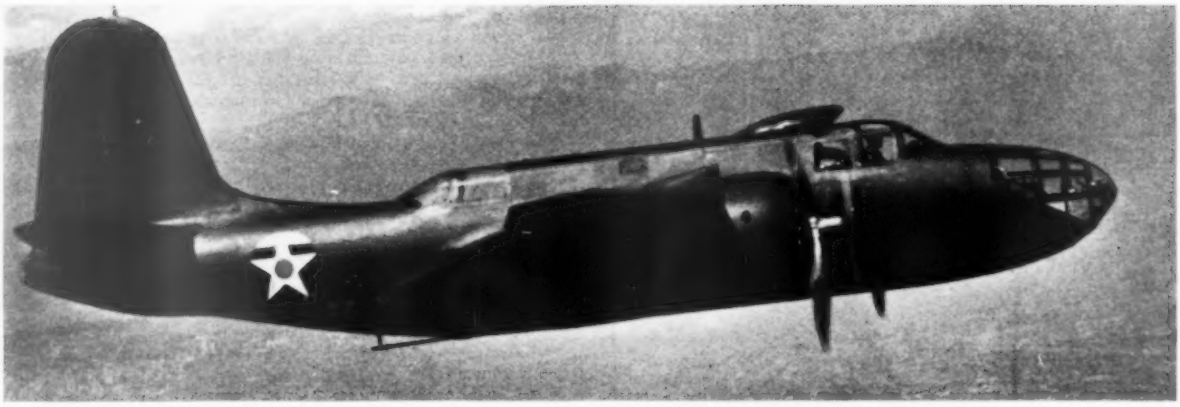
If these vulnerable and sensitive sinews are destroyed, or suffer serious injury, the entire industrial, social and economic fabric is affected. The degree of injury determines the extent of damage to the structure. An individual becomes weak and ill as his red corpuscles are destroyed and the white corpuscles assume control. The red corpuscles of modern industrial nations are made up of its industry, its communications and its national morale. When these are seriously injured the white corpuscles come into the ascendancy and the nation becomes economically ill and weak. Its ability to wage war successfully becomes endangered.

Before the advent of air power, as we are witnessing it today, it was possible for powerful armies and navies to protect their countries' economic and social structure by meeting hostile forces beyond its frontiers or its shores. Today air power, by means of its bombardment aviation, makes it possible for a nation to reach far out over the seas and threaten the sea lanes of communication; it reaches hundreds of miles into the interior of nations and strikes at the vulnerable and vital industrial life; it employs its power against the homes of noncombatants in its attempt to disintegrate the will to resist of the people; by striking at the port facilities of great cities it threatens a nation's communications.

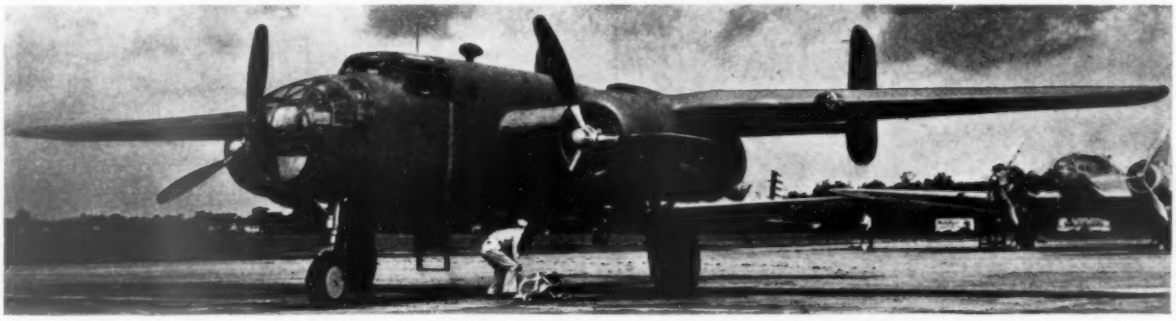
While the employment of air power has, admittedly, wrought a tremendous change in the conduct of this war over the past conflicts, and while it has made possible victory after victory to the side possessing air superiority, many people are asking why the German *Luftwaffe* has not been successful in inflicting

First Army airplane to be contracted for "off-the-cuff" was the Martin B-26. A medium bomber powered with two 1,850 h.p. engines, the B-26 is faster and deadlier than most current pursuits.

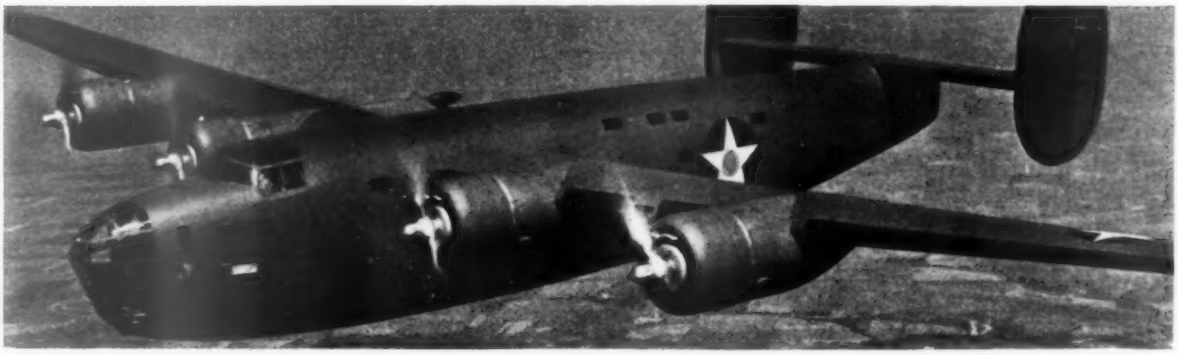




First in the Army's new light bomber category is the Douglas A-20A above. Though it still bears the Army attack designation, the tricycle-geared A-20A replaces the discontinued attack airplane.



In the same class as the much-publicized Martin B-26 is the North American B-25 medium bomber. Ranked between the A-20A and B-24, the B-25 follows the Army's multi-engined, tricycle-geared pattern.



Only Army Air Forces heavy bombers are the newest Consolidated B-24 above and the Boeing B-17 below. Accepting the B-24 in record time, the Army ordered hundreds to be built in several plants.

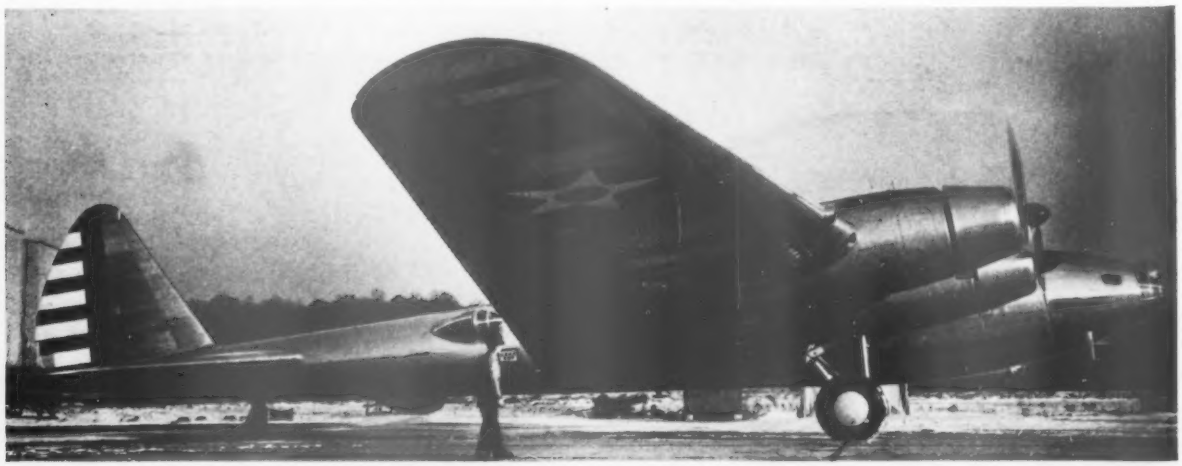
EVOLUTION OF THE BOMBER

Many designs led up to present-day Army bombers. From top to bottom are the six-engined Barling bomber of 1925, the twin-engined Martin which followed in the same year, the trim Boeing "flying pencil" of the early 30's and the veteran Martin B-12 which preceded the current Douglas B-18A's.

a decisive blow against the concentrated industrial and economic structure of the British Isles. Surely say many, if there ever existed an ideal objective for air power, the British industrial machine is it. However, it is still functioning even after the passage of nearly a year of German air operations against it.

The answer is not too difficult to understand. Modern air power is relatively a new agency of warfare. In its present status it has been created in an extremely short period of time; actually not over a half a dozen years. It is not surprising that vital errors crept into the plans of those who were its principal exponents. Fortunately, for the world, those errors affected German air power more than Allied air power. Let me explain. The offensive component of air power is bombardment aviation. It is this class of aviation which carries the deadly demolition bomb. It is the bomb, properly placed, that destroys the vital targets in a nation's economic structure whether that target be an electrical power plant, a critical unit in a vast industrial system, an important railroad bridge or an essential oil refinery. While the demolition bomb has the capacity to destroy any important economic target, if it hits that target, it accomplishes little more than minor damage, including the making of a "big noise," if it secures a miss. Bombs released simply over an area have small chance indeed of accomplishing serious damage. For instance, as concentrated as is London, we find that there is eight times more ground not covered by buildings than there is covered by buildings. Therefore, the chances of even hitting a building, simply by releasing a bomb over London, is one in eight. Also, the chance of hitting a particular structure, that is of great military or economic importance, is many times less than one to eight. We see, therefore, that accuracy in dropping bombs is of paramount importance if the full effect of air power is to be realized. Since seeing the target is essential for a bombardier to get maximum efficiency out of his bomb sight, it is obvious that the effectiveness of air bombardment is dependent upon daylight, instead of night, operations. It is here that we see where the first serious error in the development of bombardment aviation occurred. Those men responsible for the building of the German bombing airplane assumed that, with its high speed, it would be able to avoid combat with the hostile fighter or pursuit airplane. As the result of this assumption the bomber was not equipped with sufficient machine guns to protect itself from attack by the fighter airplane. As mentioned above, the world can be thankful that this vital error occurred in the *Luftwaffe* high command. That that error did occur was evidence in the skies above London last September when the German air force attempted to reduce to rubble the economic structure of the British Isles. When the RAF fighter planes and the German bomber met thousands of feet above the soil of England, it was found that the bomber was not fast enough to avoid combat. During that combat it was proven conclusively that the two machine guns in the German bomber were

An experimental flying laboratory like the Douglas B-19 on the opposite page, the Boeing B-15 was built in 1938. Also like the B-19, the Boeing was designed for larger engines than were available.



no match for the eight guns in the *Spitfire* or the *Hurricane*. In the face of the resultant losses, the German bombers could not release their bombs with accuracy and the vital and sensitive economic structure of Great Britain—without which England could not continue to wage war—was saved from destruction.

However, we must not forget that what saved England in her critical hour of need was British air power operating through the medium of her fighter command. That there can be no question concerning the correctness of that fact we have only to remember the glorious tribute from the lips of Prime Minister Winston Churchill:

"Never before in the history of warfare have so many owed so much to so few, as the people of England owe to the Royal Air Force."

German air power had threatened the continued existence of England and British air power had saved it. The RAF had saved England in that eventful September of 1940, as surely as had Nelson at Trafalgar in 1805.

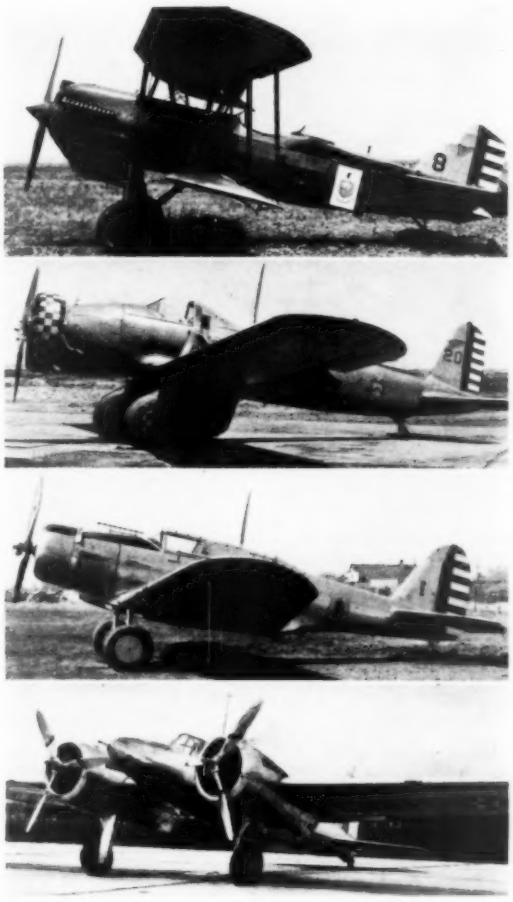
As a result of that victory of the RAF over the *Luftwaffe*, day-light operations, in strength, ceased over England and night attacks took their place. That such operations must, of necessity, be less effective than day operations is obvious. The inability to identify a particular target prevents accurate bombing. While great destruction over wide areas is possible, the probability of destroying the keypoints in the economic structure is greatly minimized.

However, it must be remembered that the history of warfare teaches one lesson over and over again—for every offense there has always been developed an effective defense. Air power still is in its infancy. The bombers we see today will no more compare with the bomber of "tomorrow" than the frigate of the sailing navies compare with the super-dreadnaught of today. The designers of aircraft, and the great aircraft factories, may well be depended upon to produce the bombardment airplane with adequate armor and gun fire to protect itself from the fighter airplane. To assume that it is not possible is to refuse to recognize the lessons which warfare have written the blazing words across the pages of history.

It is air power, the fear of the terrific destructive power of the bombardment airplane, which makes it impossible for British naval units to plug up the points of sortie of the German submarines. Without air power it would be possible to conduct mining operations and small naval patrols close to German occupied ports, and in the North Sea, thereby minimizing the effectiveness of the submarine. Without air power, the merchant marine of the world carrying supplies into the British Isles could operate with minimum risk. Had it not been for air power, Norway would not today be occupied by the German army.

Indeed, air power has left its impress upon the entire conduct of the present war. If its results have not been conclusive there exists no doubt in the minds of all military men

THE ATTACK PLANE

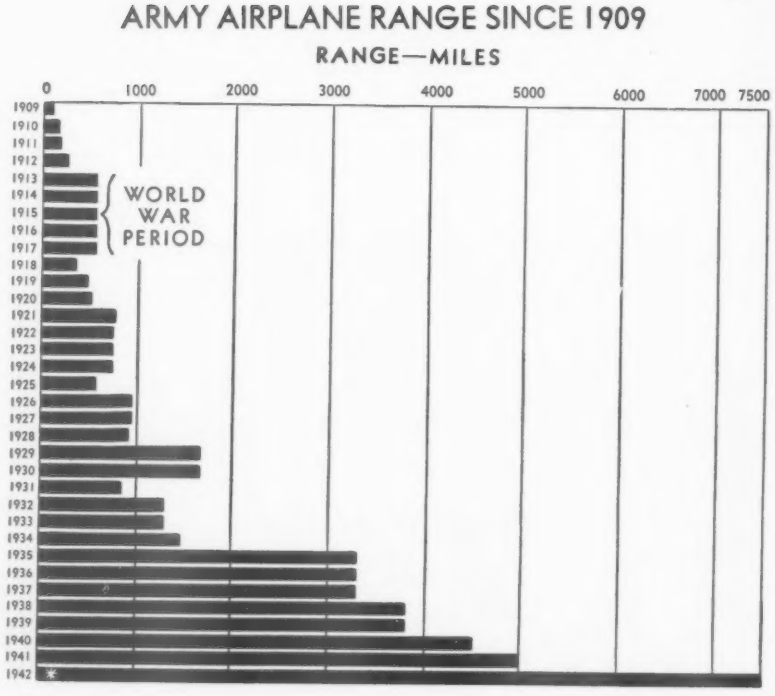


Strictly an American invention and direct predecessor of the light bomber, the attack plane brought about many new designs. From top to bottom are the Curtiss A-3B of 1929 and A-10 of 1932, Northrop's famed A-17A and the Curtiss A-18. Note latter's trend toward light bomber design.

Contrary to popular opinion, the Douglas B-19 is not a combat type and was built for experimental purposes only. Everything on it, from tires to propellers, had to be specially designed and built.

Modern bombers like this Martin B-26 (above) carry bomb loads inside their fuselages in racks. Bomb bay doors are controlled automatically from cockpit.

Asterisk in 1942 bar on chart (right) shows announced range of the Douglas B-19. It is expected that near-future designs soon will approach that figure.



that ultimate victory will go only to that side which possesses superior power in the air.

Air power has surely taken its place as a vital and important agency for the waging of war. It will not be outmoded tomorrow. The world has learned that it cannot spring into being overnight. It cannot be created by following in the footsteps of others, by duplicating the accomplishments of potential enemies. Vision and far-sightedness must bring into being the airplanes and aerial equipment superior to those of the enemy. The fortunes of war will follow the nation that has superior power in the air as certain as day follows the night.

For democracies to continue to live they must be stronger in the air than the forces that seek to destroy them.

END

Surest protection against bombardment is the fighter. The U. S. Army has the world's finest.

Curtiss P-40.

PURSUIT

by Maj. HOYT VANDENBERG

A West Pointer, Major Vandenberg, native of Wisconsin, joined military aviation in 1923. He is 42, a graduate of the Army War College and tactical school and holds ratings as command pilot, corps observer.

PRESENT pursuit or fighter planes' development can be traced back to the Army's first Wright military ship, in which the passenger held a machine gun between his knees. Specialized functional development of planes had not yet taken place. During the World War, however, such types as the Nieuport, Spad, SE-5, Sopwith *Camel*, Fokker and Albatross were developed. These had a performance margin over ships designed for load-carrying or observation work and were armed with one or two machine guns.

Left-over wartime equipment was in general use for many years. A new trend appeared about 1923, when racing airplanes were developed and their military counterparts produced as fighters. Among these were the Army USXVP-1, from the Air Corps Verville Packard racers and the Curtiss PW-8, and from the Curtiss Army and Navy racers. These were followed by small, highly-maneuverable biplanes equipped with 400 to 600 h.p. engines and two guns. Performance increased slightly as time added technical developments and increased horsepower. In this family were the Curtiss *Hawks* and the Boeing P-12 series.

By 1932, increased performance demands brought such transition models as the P-26A, with its wire-braced thin monoplane wings. Next came the Seversky P-35 and the Curtiss P-36. These allowed increased weight-carrying capacity and power without essentially modifying the basic design. During 1939 and 1940, tremendous increases in power, performance and required load have produced planes which, although similar in general appearance, actually have different standards. Some of the handiness and ability to operate from small fields has been sacrificed for high speed and carrying capacity.

Fundamentally, the pursuit airplane is a relatively small, high-velocity projectile carrying a pilot to direct the missile to intercept and destroy other projectiles in flight. The sustained speed of modern airplanes is equal approximately to the average speed of some of the large size artillery shells.

In order to make interception at all, the pursuit ship's outstanding characteristic must be high performance. Most interception depends on ground direction. Observers report an enemy aircraft's positions and give interception directions to the friendly pursuit aircraft. The pursuit airplane acts as a mobile antiaircraft unit which can be directed outside the range of normal antiaircraft fire and whose course can be changed at will after the projectile is fired.

Pursuit planes may be used to patrol areas where enemy aircraft are expected in the hope of making chance interception. In the last war, pursuit units had daily patrol missions on which they picked up targets as they presented themselves.

There is also the problem of supporting friendly aircraft. The pursuit plane is supposed to engage enemy fighters and prevent them from interfering with bombardment or reconnaissance missions. In simple terms, the pursuit ship places itself between the possible enemy attack and the planes to be protected, thus greatly deflecting the attack itself. If the pursuit breaks off its protective duties for a fight, the friendly planes will be forced to go on unescorted.

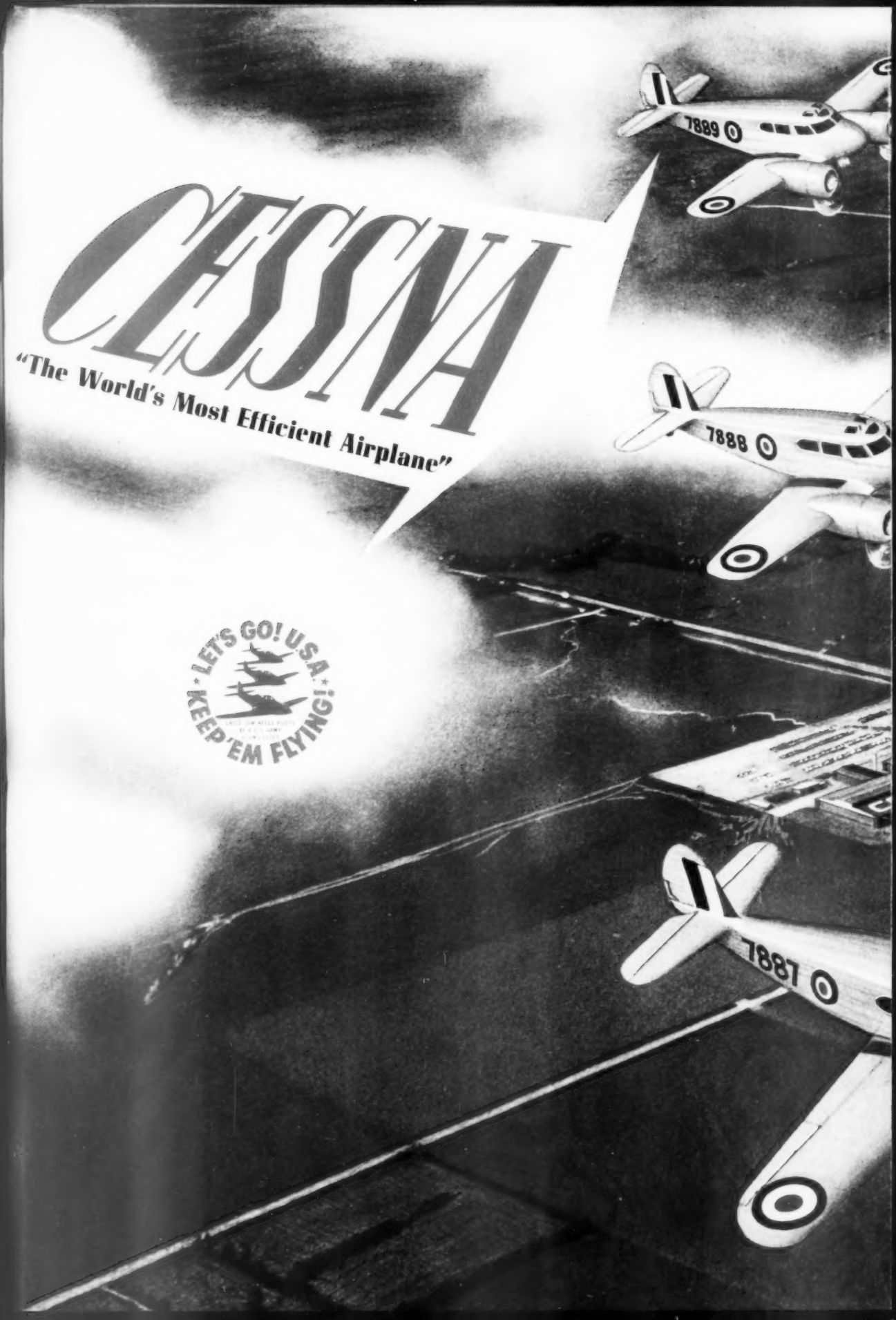
In general, then, the pursuit plane has a purely defensive function, but the way it carries out this function is always offensive. It is designed, built and flown with the fundamental idea of carrying the fight to the enemy. If performance is insufficient to provide interception or give an advantage in maneuvering, the ship has no reason to exist; it is of more benefit to the enemy than to friendly forces, for it requires maintenance, supply and personnel almost to the same degree that a superior one would.

Performance must be gauged in broad terms, however. It is a composite of measurable items like climb, speed and ceiling, plus a great many intangible characteristics such as handling, maneuverability, acceleration in dives and the ability to make sharp turns at low speeds. Speed differences are not necessarily the deciding factor.

A pursuit pilot must determine his ship's strongest features and exploit them fully, as well as avoiding maneuvers in which the enemy has the advantage. Thus, a skillful pilot

(*Continued on page 59*)

Stock 1936 pursuit was the Seversky (Republic) P-35. Outgrowths are P-43 and P-47.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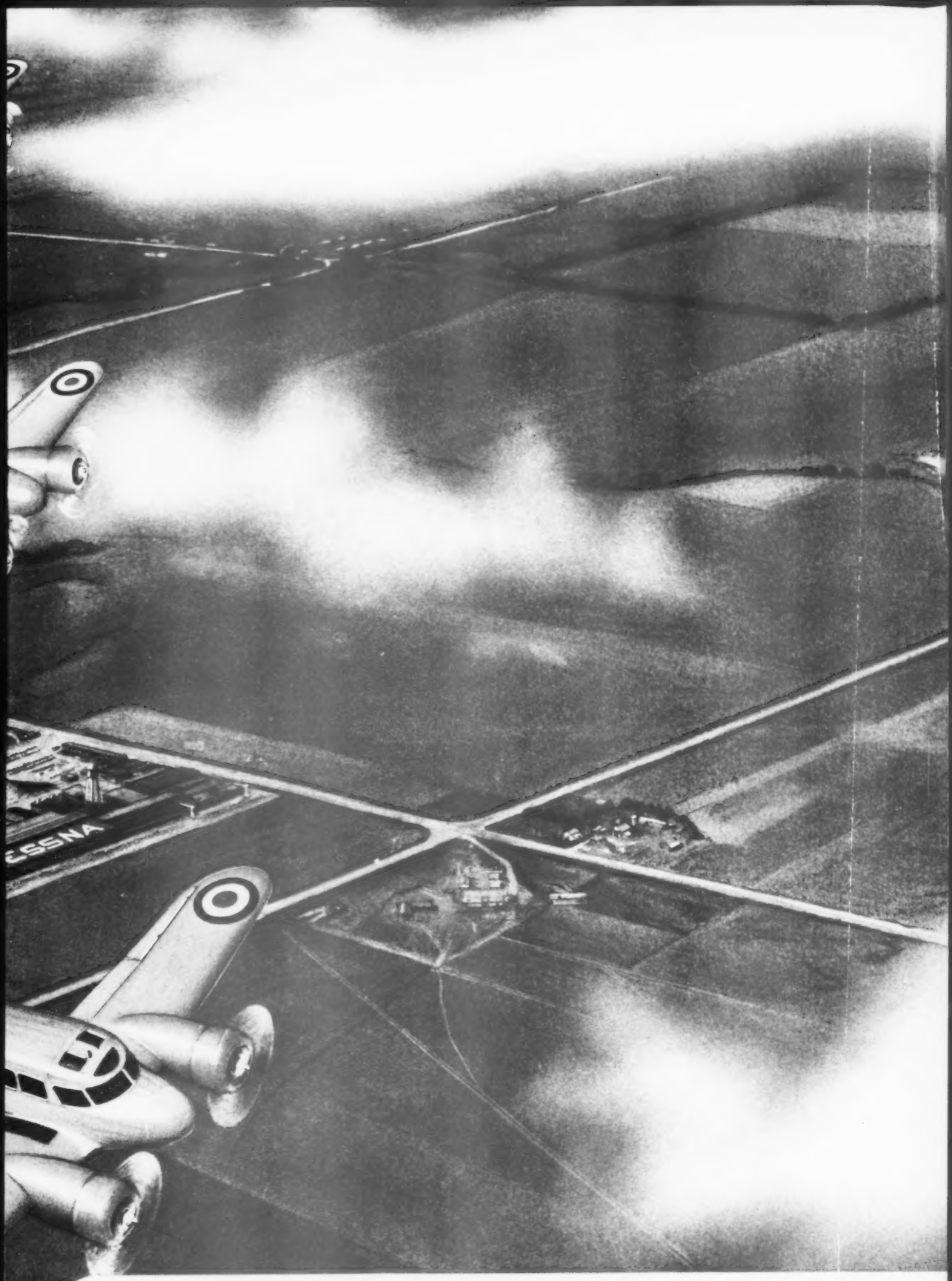

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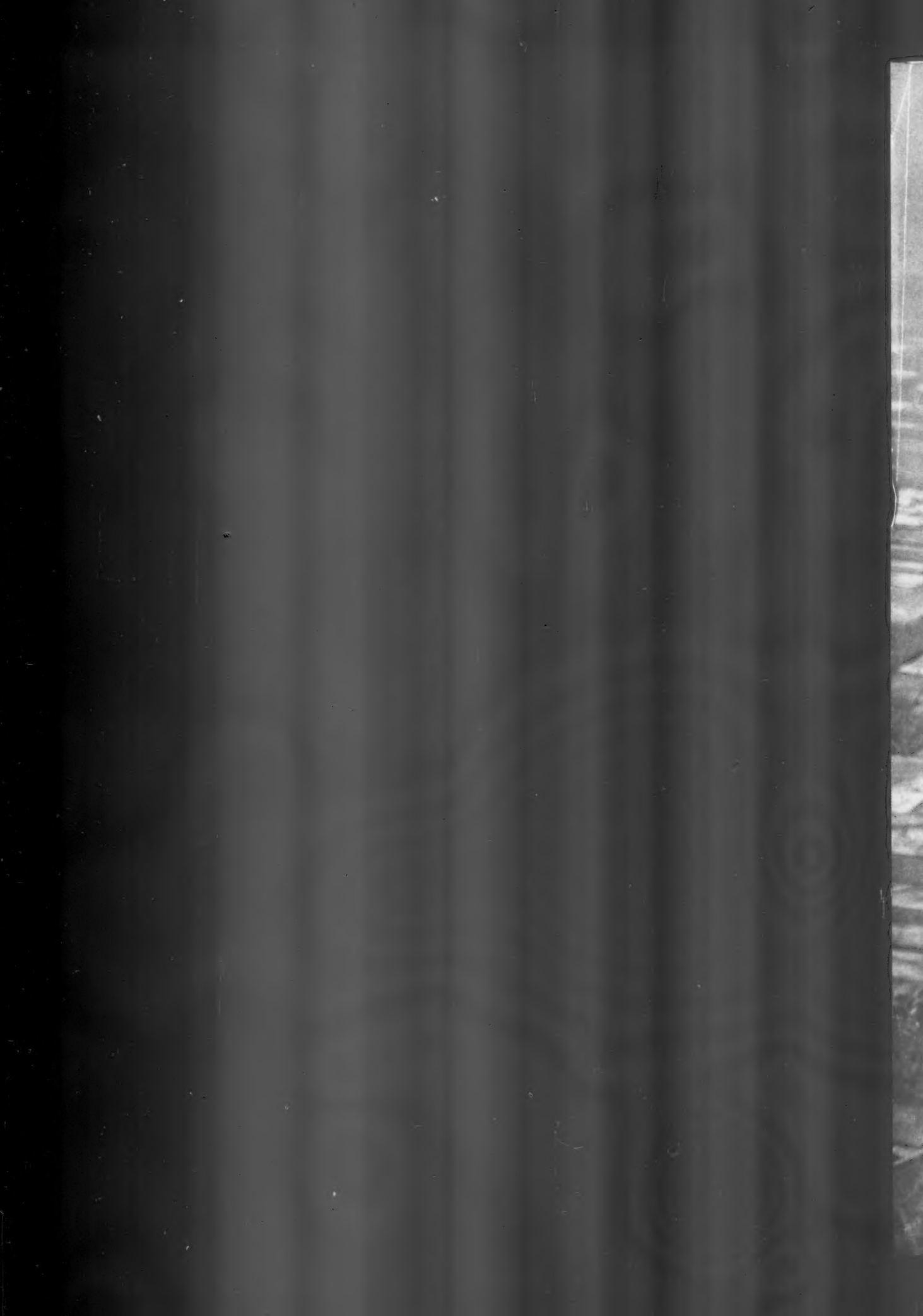


The Lockheed P-38

by Rudy Arnold

Standard "conventional" Army pursuit is the Curtiss P-40 above. It is an Allison-powered successor to the P-36A which it replaces. XP-42 (right) was experimental P-40 with an extended-shaft radial.

may utilize a somewhat inferior plane's strong points to establish a stalemate in which the enemy can never get sufficient advantage to be sure of victory. An unskilled pilot with a superior airplane, on the other hand, may make the fatal mistake of trying to beat the enemy on the enemy's strong ground.

Pursuit pilots always are investigating their own types' performance limits in order to determine unusual maneuvers which can be employed to their opponents' disadvantage. The Germans' Messerschmitt Me-109, for instance, has a known tendency toward stiffening of the controls in high-speed dives, making it extremely difficult to recover after a dive has been well established. In several cases RAF pilots have tricked Messerschmitt pilots into low-altitude dives, with the result that the Me-109's plunged into the ground or sea.

To deliver a successful blow, pursuit planes must carry sufficient fire-power to destroy their opponents. Extremely effective armament installations are possible with several gun arrangements. There always will be considerable variation between different planes, due to day-to-day considerations, design of the planes themselves and changes in tactics.

Considering pursuit planes as projectiles, it might be assumed that a plane can bring down any enemy with which it can collide. Machine guns, bombs, or other armament, may be rated defensive measures enabling the pilot to make several attacks with less hazard than in collision. Armor plate accomplishes the same thing. But unless its guns actually provide more victories than could be won by collision, it is obvious the pursuit plane's striking power has not been increased. This explains the tremendous armament increase in present pursuit types and the tendency of fighter pilots to carry the attack to close range in an effort to equal actual collision's effectiveness.

Modern metal airplanes can absorb a great deal of small-caliber fire, making necessary installation of many guns. The extremely effective British *Spitfires* and *Hurricanes* both employ eight guns. Armor plate minimizes effectiveness of small-caliber hits, however, and there is consequently a general trend toward heavier caliber guns. This in turn raises problems of greater weight, smaller rates of fire and other attendant difficulties. There is no final answer to the problem of armament versus armor and no one solution provides 100 per cent insurance of success in combat.

Suggestions that all equipment, instruments, etc., should be eliminated from fighting aircraft in wartime have their answer in the present conflict, where both sides' planes are as well-equipped as they ever have been. Numerous new devices designed to improve combat efficiency have been added. Neither radio nor flying instruments can be sacrificed if a plane is to have maximum utility. The days of small, light, simple pursuit ships with nothing on the instrument panel but an airspeed indicator, tachometer and oil gauge definitely are gone. Automatic propeller control, retractable landing gears, flaps and other modern accessories are absolute essentials for performance and, often, safety, despite attendant increased complication.

Since it takes at least two years to get even a relatively simple pursuit ship into production after its initial design, many American planes now being manufactured obviously are simply modifications of others designed and pretty well fixed in their details long before the present war. It is remarkable that they have been able to go through such tremendous changes and still function. For example, today's Curtiss P-40 is basically the old P-36, initially delivered four years ago. Weight increases to accommodate new armament requirements, armor, leakproof fuel tanks, heavier power plants and structural changes made necessary for improved performance, have amounted almost to carrying a 2,000-pound bomb on the original P-36. Yet refinements in design and technical improvements here and there have permitted absorption of this tremendous weight increase.

Initial design of the Army's Bell *Airacobra* (the P-39) and Lockheed P-38—which give promise of being two of 1941 and 1942's outstanding planes—was begun in 1935. They have been considerably modified and projected from the originals with-

THE PURSUIT PLANE

Some of the most radical changes in military aviation have been made in the pursuit airplane. The four types, dating from the World War, are, from top to bottom: the SE-5, the Curtiss P-1 of 1930, the famed Boeing P-12E of 1933 and the Boeing P-26A of 1936, first of present monoplane fighters.

out unduly jeopardizing their most outstanding characteristics.

Performance figures usually represent data obtained during test of one ship to determine its compliance with design guarantee. Although all planes of like design should have the same performance under the same conditions, in service—with average pilots and perhaps with engines not completely tuned for maximum output—there will be variation. Performance figures, therefore, are not always criterions.

There is a group bracket wherein performance figures describe comparable planes. For instance, ships having high speeds of from 350 to 365 m.p.h. are in a 360 m.p.h. class; from 375 to 390 m.p.h., in the 380 m.p.h. group; and from 395 to 415 m.p.h., in the 400 m.p.h. group. These speeds, in turn, are modified by altitude; an airplane which will fly 400 m.p.h. at 20,000 feet has a much lower top speed than one which will fly 400 m.p.h. at 15,000 feet. There is a tendency to classify pursuit airplanes into low altitude type (with best performance at from 12,000 to 17,000 feet, obtainable without intercoolers or exterior supercharging) and high altitude type (having critical altitudes above 20,000 feet, utilizing additional compressors, either engine-driven in the case of two-stage engines, or using turbine superchargers).

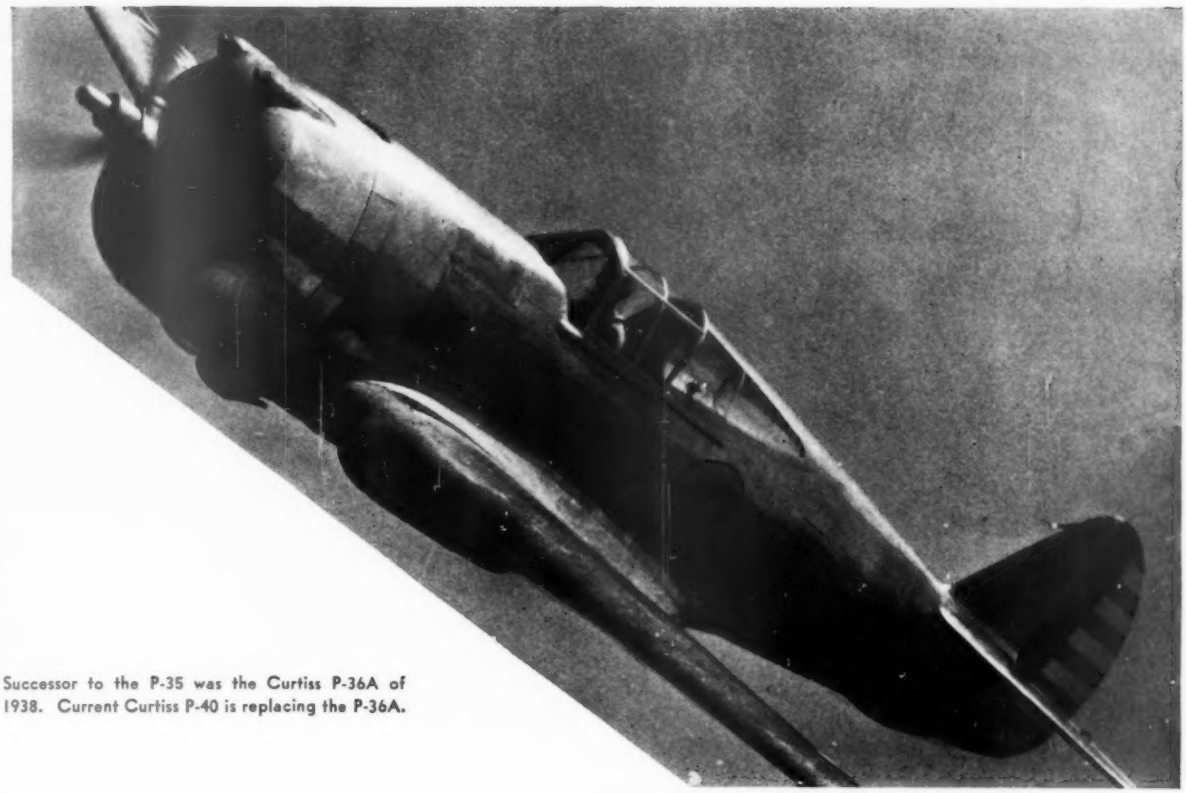
Curtiss P-40's now being flown in service are an example of the 350 to 360 m.p.h. plane at altitude up to 15,000 feet. These ships include modern armor, bulletproof tanks and armament comparable to present European planes. Later P-40 models have more speed and considerably increased armament, making greater use of the larger caliber machine guns. The Bell P-39's present models fall in the over-400 m.p.h. class It likewise includes war-prompted modifications, plus 37 mm. cannon. Lockheed's P-38, now in production, is an interesting version of the two-engined pursuit airplane. It actually has demonstrated top speeds above 400 m.p.h.

The two-engined pursuit airplane was laid out in a time when there was insufficient power available in single power plants to attain the performance and carry the load necessary. With development of larger engines—2,000 h.p. or more—single-engined pursuit planes became possible, as in the Republic P-47, which uses the large 2,000 h.p. Pratt & Whitney engine. This airplane, although designed for a single man and supposedly being a small pursuit ship, is heavier than many transport planes of a few years ago. It carries almost a ton of guns and ammunition.

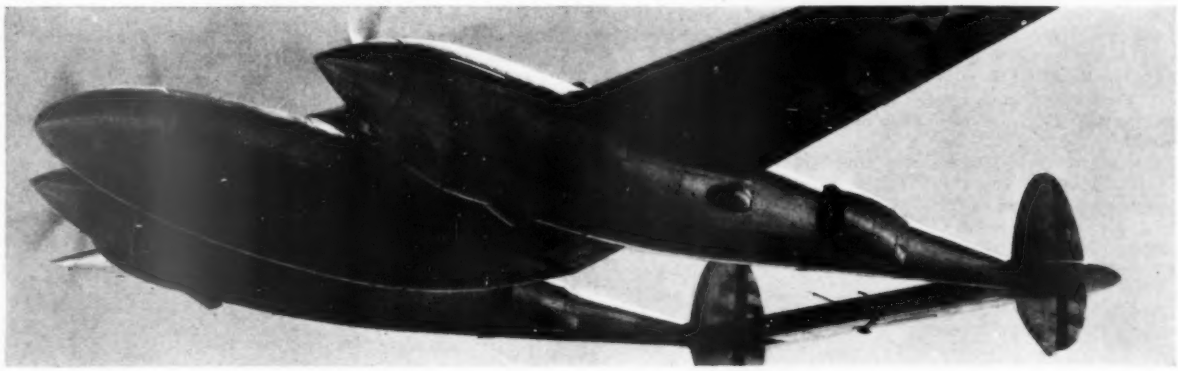
The present race for altitude is like that of the last war, when the advantage rested with the plane having the ability to reach higher altitudes—around 20,000 feet—than its opponents. Now the struggle is to heights of 35,000 to 40,000 feet.

Distinct and unique problems are connected solely with speed. As we approach sound's speed—roughly 600 m.p.h.—the air forms compression waves and resists passage through it. Pursuit airplanes, even today, have diving speeds in which these compression effects are very noticeable. Around the plane are certain local regions where the air is speeded up so that it actually attains velocities approaching the speed of sound, although the ship's speed itself is still below it. From

Joint development of the Bell company and the Army was the YFM-1A or "Airacuda." This is first attempt to develop and perfect the long-range, heavily armed escort fighter to accompany bombardment missions.



Successor to the P-35 was the Curtiss P-36A of 1938. Current Curtiss P-40 is replacing the P-36A.



Now going into Army service are Lockheed P-38, above, and Bell P-39, below. Both are powered with Allison engines. Each is armed with a 37 mm. cannon in addition to numbers of .30 and .50 caliber machine guns.

Latest Army interceptor is this Republic P-47, the most powerful single-engined fighter in the U. S. The P-47 is heavier for its size than a battleship. Note four-bladed propeller and wide gear.

these little sore spots come tremendous drag increases. They must be eliminated if planes are to attain much higher speeds. Air loads on windshields, wings and cowlings are so great also that the structural design problem becomes difficult.

Delivery rates on pursuit planes, smallest fighting craft, have been stepped up to as many as 10 a day from plants not particularly expanded to meet the present emergency. Because so much material is included in such small space, however, pursuits are unusually intricate, complicated and difficult to construct. The P-38 and others like it are heavier for their size than is a battleship.

Such present airplanes as the Bell P-39—and the Curtiss P-40—represent the modern production pursuit ship. The large, single-engined, 2,000 h.p. planes like the Republic P-47, the Navy Vought-Sikorsky fighter, or the twin-engined Lockheed P-38, may indicate a future trend. Every past effort to make small, light airplanes serve as fighters has been unsuccessful.

The future definitely holds promise of 5,000 h.p. pursuit planes, 75 mm. cannon and fighters weighing up to 30,000 pounds gross. Just where all the developments will fit into the picture and how important a part some of the smaller compromise solutions may play is uncertain, but the trend has been and appears to be toward bigger, better, faster and harder-hitting pursuit ships.

Although designated as a fighter and not a pursuit, but with basically the same characteristics and fundamental purpose, the YFM-1 Bell *Airacuda* is the large type plane which, in the future, probably will be the pursuit or escort types.

Little has been said about the Bell since it was conceived several years ago, but General Arnold on several occasions has been known to remark that it is the "smoothest designed ship that I have ever seen and we expect great things from this airplane."

Brig. Gen. George C. Kenney, assistant chief of the Materiel Division at Wright Field, said recently that the ship "is by no means through as far as the Army is concerned. There has been a lull in development, perhaps, but that has been for a period in which we had to iron out the bugs. After all, the ship is of radical design and many new changes developed from the original model before we began to get the kind of performance out of it that we wanted."

Originally, the *Airacuda* with its pusher-type Allison engines located in wing nacelles, which also house machine gunners in front compartments, was designed to incorporate 1,500 h.p. engines. Only recently has sufficient horsepower been made available in the in-line motor so that such engines could be installed for test purposes.

The YFM-1, however, is the only U. S. fighter plane today that is designed to carry two rapid fire 37 mm. cannon, one in each engine nacelle where gunners sit in front with excellent vision.

The real necessity for such large planes as the *Airacuda* arises when one considers the great height and distances that modern bombers travel on their night or day missions. Army engineers long have been faced with a problem of designing a fighter, or convoy plane for the big *Flying Fortresses* which could carry enough fuel, high enough and far enough, to help insure the success of long range bombing expeditions. Considering that we are defending not only our continental U. S. but the entire western hemisphere as well—and that our military experts are relying on air power to do the job—such a fighter plane has through necessity been skyrocketed into demand

Fighter planes of tomorrow, patterned greatly around the basic idea of the Bell multi-place fighter are on the boards of our engineers right now. They may not necessarily incorporate all the YFM-1's features, but their general design will be toward heavier armament, possibly even three and four of the 37mm. cannon and six or eight .50 caliber guns, and they will carry a crew of from three to five men, creating virtually impregnable fortresses of themselves, yet maintaining considerable maneuverability and striking prowess which the big bombers lack.

Bear in mind that, in order to defend our shores far out at sea, as is the general plan—hence all our air bases that are 1,000 to 1,500 miles from our coastline—our defending fighters, the only real antidote for attacking bombers, must be able to have fuel capacities to keep them in the air for longer periods than the smaller pursuit planes.

But in addition to these outstanding characteristics, the larger type plane has other advantages. It can reach higher altitudes—25,000 to 30,000 feet—without losing too much of its performance, which smaller pursuits haven't been able to do yet. Bombers every day are reaching new heights, some even are flying at better than 40,000 feet, creating a new battlefield, out of range of antiaircraft fire and most fighter planes. Experiments already carried out with the YFM-1 type have proven that ships of this size can reach the upper levels and still retain their effectiveness.

The larger planes, utilized as fighters not only will be able to carry more guns of the heavy caliber type, but they will carry much more ammunition. Shells of .75 mm. variety haven't yet been tried in these ships, but they are definitely being planned for use in the future. As the airplane is increased in size it allows for added armor plating which will require increased fire power to penetrate into its vital parts. Bigger guns, from necessity, will have to be employed.

In the opinion of the author we have successfully licked the problem of speed in our modern airplanes, but we must concentrate on size and fire power in order to strike more forcefully at any enemy. Larger fighters packing plenty of wallop in guns will do the trick.

END

RECONNAISSANCE

The success or failure of any military operation can, and usually does, depend upon information relayed by reconnaissance planes.

North American O-47A's.

RECONNAISSANCE and OBSERVATION

by Lieut. Col. HOWARD A. CRAIG

Philadelphia born, Lieutenant Colonel Craig enlisted in the Aviation Section, Signal Corps, during World War. Rated a command pilot and corps observer, he is assistant chief of new plans division.

AIRPLANES have brought about many changes in military tactics, but none is more fundamental than use of reconnaissance and observation planes. For the first time, generals are able to see their enemy's strength, disposition, condition and movements. The reconnaissance and observation forces are the modern army's eyes.

Reconnaissance and observation planes' job is to seek out, record and report back all information possible about the enemy. The words "reconnaissance" and "observation" describe separate functions in our Army. Reconnaissance is scouting work carried out on behalf of the aerial striking forces. Observation is similiar work done for ground troops.

Reconnaissance missions for the Air Forces get information about possible bombing targets, or flights of enemy aircraft. Such missions may be defensive or offensive. At the opening of hostilities the Air Forces commander dispatches his reconnaissance forces to get information about important bombing targets. At the same time, strategic reconnaissance patrols are sent up to watch for the approach of enemy forces by land, sea or air—which likewise may become Air Forces targets.

The Army has planes especially designed for observation work, but reconnaissance planes are aircraft of standard combat types which carry special equipment for their work. The reconnaissance plane must sweep over big areas of land and sea and therefore must have considerable range. Bombers, chiefly, do for reconnaissance; as a rule the same type of plane is used as will go on the bombing mission to follow. The reconnaissance planes must be able to report exactly on all conditions which the bombers will encounter, estimating the time required to fly the mission, the gasoline load, the best route and altitude, etc. Instead of bomb loads, they will carry extra gasoline, in special tanks, in order to stay over the target area longer.

A commander will not send valuable bombing planes out on missions until he knows exactly where and what the target is and the conditions to be encountered. Bombardment units, before they take off, are furnished with what the Army calls objective folders, prepared largely on information furnished by the reconnaissance squadrons.

It is not enough to tell a bombing squadron there's supposed to be a big gun emplacement or a motor parts factory outside some town. They must be told just exactly where it is; must be familiarized with landmarks to help them locate it; and must be given pictures which will simplify their identification of the objective. The reconnaissance squadron must search through enemy territory for possible targets, then make detailed studies for the bombers. This is a job which must be done every day of the war, since targets are moved, disappear—if your bombing is good—and new ones appear.

The bombardment organization will want details on the target's nature. If it's a factory, how big is it and how camouflaged? Are there secondary objectives nearby, such as ammunition dumps or storage places, which should be bombed also? How well is the territory guarded? If the antiaircraft gun emplacements are numerous, the attack may be made from a greater altitude than if the defense is skimpy. Late weather reports also may be required to determine the ceiling under which the bombers must get or to reckon the wind velocity for the bombardiers. At night the target must be illuminated by flares or incendiaries.

The reconnaissance planes also must bring back information needed to compute the number and size of bombs. If the target is built of steel and concrete, the heaviest size bombs may be needed to wreck it. If of flimsy wooden construction, a few incendiaries and light bombs may do the job.

These squadrons' work becomes more important as actual battle approaches. They search deep behind the enemy lines to report movements of men and materials; to seek out airdromes where attack planes may be concentrated. If our country were threatened with invasion, for instance, it probably would be the reconnaissance planes which first would discover the approach of enemy transports.

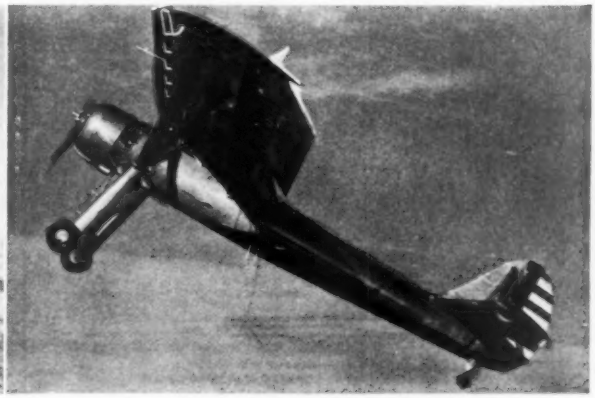
In addition to surveying the ground, reconnaissance patrols may be set up to guard the sky. This is one of the most complicated functions of reconnaissance. If an air attack was suspected along one of our coasts, such an aerial reconnaissance might be called for. The possible routes which enemy planes could take would be set off for the patrol. Then certain squadrons would be assigned to definite areas and units of these squadrons would patrol different levels. When the enemy craft were sighted, the reconnaissance units would send back information on their type, strength and location—but would not attempt to engage them in action.

Group of Boeing B-17's demonstrated vital long-range ocean reconnaissance by intercepting liner "Rex" 776 miles at sea.

This device enables observation plane, such as North American O-47A, to catch messages on the fly from almost anywhere two poles can be set up.

Flaps and slots help cut flying speed of Stinson O-49, currently standard observation and liaison plane. Power: 280 h.p. Lycoming engine. Observation planes differ from reconnaissance in that they are intended to reconnoiter for ground Army.

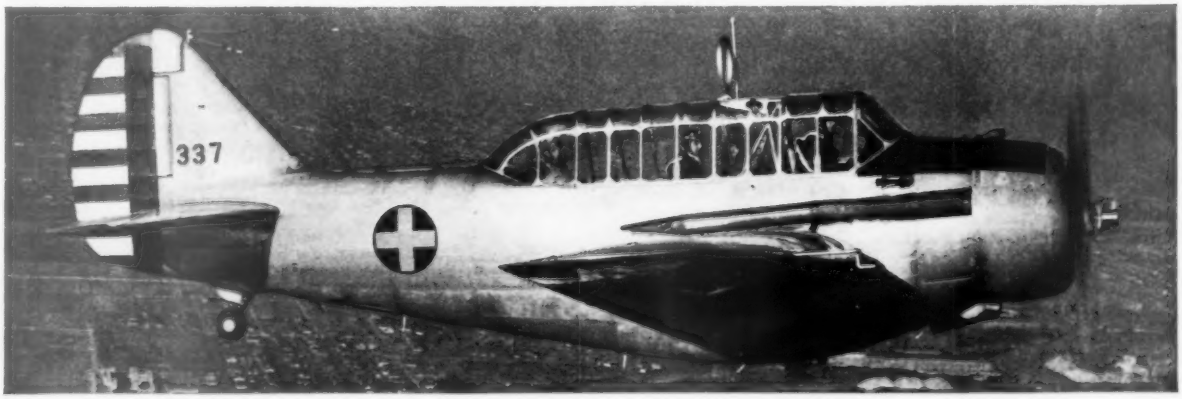
For reconnaissance missions Army uses regular combat types, such as this camouflaged North American B-25 medium bomber.



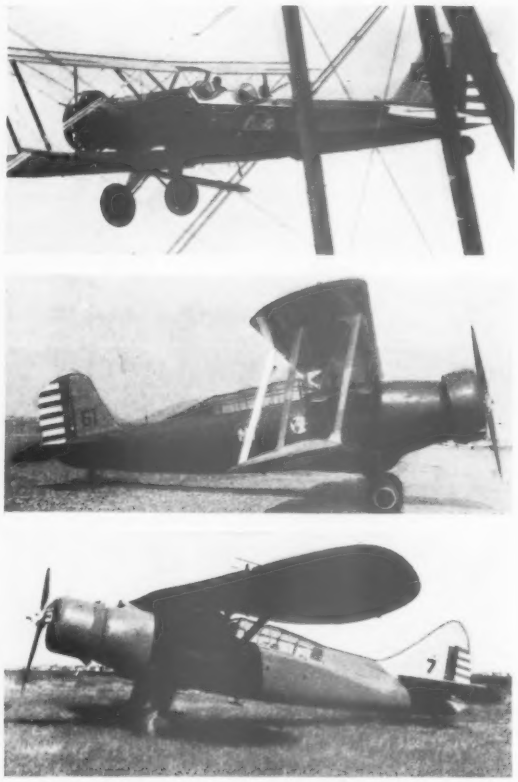
Ryan YO-51, liaison ship, can land in small, rough areas. It is used to carry commanders aloft to make own observations.

Kellett YG-1B autogiros, two-place ships, have been replaced by observation and liaison ships like those shown above.

Another standard observation type is the speedy, three-place North American O-47A, which operates with ground troops.



THE OBSERVATION PLANE



A few steps in observation plane evolution are traced in these photographs of ships of this type during the 1937-1939 period. Top, the O-38; center, O-38F; bottom, O-46A. Observation planes no longer rely on altitude for protection. To escape destruction they need speed and armament.

The size and make-up of a reconnaissance crew is determined by the type of plane used. Most large bombers carry a pilot, co-pilot, navigator, radio operator, a skilled observer-photographer, possibly a flight engineer and gunners. This crew must be a highly skilled team; if they do not do their jobs well and quickly, the mission's chance of success will be reduced sharply.

One of the most important reconnaissance instruments is the camera. Tremendous strides in aerial cameras' development and the use of photography have eliminated from reconnaissance work most of the human element which in the past made observers' reports uncertain. The Air Forces use many kinds of cameras, described in more detail in the article on photography on page 98.

In the Combat Command tactical branch, reconnaissance planes are formed into squadrons. The commander of each wing of bombardment planes—consisting of about 50 ships—has two squadrons of reconnaissance planes under his command. Without them, the bombardment wing would be stabbing in the dark.

Observation planes, although a part of the Air Forces, actually function as an integral part of the ground forces. Observation planes keep ground troop commanders informed fully on activities on the ground in the area in which he is operating. In addition, observation planes may be assigned to check artillery fire or to carry out liaison missions between separated groups of ground troops. They may check on movements of enemy troops to and from the front lines, or on vehicular traffic, locating enemy concentrations or artillery emplacements; or report on an action's progress; or check and correct maps. The observer is the guardian against surprise flanking movements or surprise withdrawals.

Each division of ground troops has attached to it an observation squadron of from 10 to 13 planes. When several divisions operate together as an Army corps, each division commander uses his observation squadron to keep up with developments in his own sector. The corps commander, in addition, has his own observation. These planes cover the entire corps sector, seeking out information which the corps commander needs to maneuver his divisions. Generally, they will range back further behind the enemy lines and over a wider front than the division observation squadrons. Similarly, when several corps are operating together as an army, the Army commander has his own observation squadrons which cover the entire front for which he is responsible.

There are several types of observation planes. Many more are in process of development. Specifications for these planes now are being changed. Before the current war started it was believed that observation planes could be slow and lightly-armed. The Battle of France showed this to be fallacious. The Germans sent up pursuit ships with the sole objective of shooting down all the French observation planes in sight. The Air Forces now believe that observation craft must be fast and well-enough armed to take care of themselves in a scrap. For this reason, some bombers—such as the Douglas A-20A—are being assigned to observation work.

For liaison work, with units such as divisions and corps, it is often necessary to use small, rough landing fields. An outstanding example of a liaison plane is the Ryan YO-51, called the "flying motorcycle." This is a two-place, single-engined, high wing monoplane, powered by a 420 h.p. Pratt & Whitney nine-cylinder radial engine. It has a 52-foot wingspan, length of 34 feet 5 inches and height of 11 feet 1 inch. Although not fast, it is highly maneuverable and capable of short landings and quick take-offs.

Standard observation plane types include the comparatively speedy North American O-47A. This is a three-place, mid-wing single-engined monoplane with retractable landing gear and tail wheel, with a 975 h.p. Wright *Cyclone* engine. A later version of this type of plane is the Curtiss O-52, shown in the color section elsewhere in this issue. This is a high-wing, strut-braced monoplane, slightly smaller than the O-47A, powered with a Pratt & Whitney engine.

Another desirable factor in observation planes is an extremely low minimum flying speed, to enable them to hover over an area. The Stinson O-54, a military adaptation of the Stinson "105" lightplane, is such a ship. Several have been turned over to the armored divisions. The ship is a two-place, high-wing strut-braced cabin monoplane, with 34-foot wingspan. It is powered by an 80 h.p. Continental A-80 engine. The Stinson O-49 long has been a standard observation plane. It is a high-wing monoplane, with a 51-foot wingspan, length of 32 feet and height of 9 feet 4 inches, powered by a single 280 h.p. Lycoming engine.

The Germans make good use of another type of plane for observation work. This is what our Air Corps calls a liaison plane, like the Bellanca YO-50 and the Ryan YO-51. It is used to carry commanding officers to vantage points at the front where they can observe their troops' progress and conditions. It can move from one unit in the field to another and can land on small, plowed fields, or city streets. The Army knows that, no matter how well-trained an observer may be, his report to the commander loses something through being second-hand. These small liaison ships carry the commanders aloft so they can make their own observations and see small things, important in their minds, which the observer may have overlooked.

Other special types of observation planes include the Kellett YG-1B, a two-place autogiro, powered with a Jacobs engine of 225 h.p. It can make 125 m.p.h. and climb 1,060 feet in the first minute after take-off. The Grumman OA-9 is an amphibian used extensively for observation in island areas such as the Philippines. The Beechcraft F-2, the "flying camera," is a fairly speedy, low-wing monoplane powered by two 350 h.p. Pratt & Whitney engines. It was built exclusively for aerial photography. Then there are several training types which

(*Continued on page* 206)

U. S. ARMY AIR CORPS

The Combat Command does the fighting. The Air Corps supplies the guns, planes, men and equipment to do the job.

by Maj. Gen.
GEORGE H. BRETT

Tall, distinguished, calm, General Brett is Chief of the Air Corps and a member of the Air Forces headquarters staff. He is a V.M.I. graduate who has 30 years of Army service.

THE Air Corps' part of the newly reorganized Army Air Forces now is preparing to grapple with what promises to be a terrific job. This job divides itself broadly into four major responsibilities. Briefly stated, they are: One, training; two, procurement and supply; three, engineering and four, construction.

Training in itself is a responsibility of the first magnitude. The Air Corps is specifically charged with training of personnel, both commissioned and enlisted, in primary, basic and advanced pilot functions as well as specialized non-pilot functions of combat crews. This is a large order. It means that the Air Corps will be required to furnish the Air Force Combat Command with everything it needs in the way of trained personnel for tactical operations.

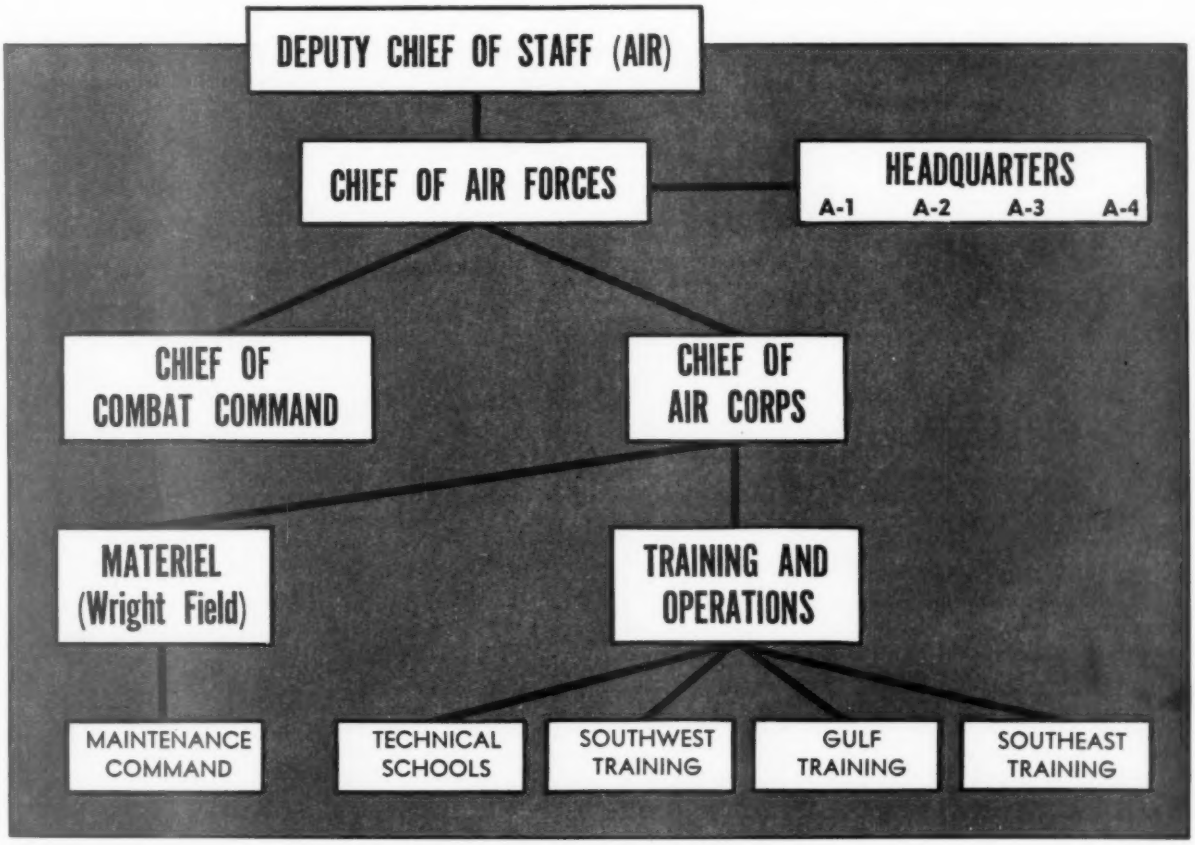
This means that the Air Corps must train not only pilots and crews as required, but that, broadly, it must train those whose duties involve the cares, supply and maintenance of aeronautical material.

Some idea of the magnitude of this task may be gained from the knowledge that the training rate for pilots is being increased from 12,000 a year to 30,000 a year, and the training rate for technicians is being increased from 45,000 a year to 100,000 a year.

Procurement and supply presents a major responsibility of the Air Corps. Pilots must have airplanes in which to fly. So the Air Corps is directly charged with procurement, storage, supply, maintenance and final disposition of military aircraft, accessories, supplies, facilities and appurtenances.

That is a terrific job, however simply stated. It affects not only the Air Corps, but hundreds of manufacturers, thousands

This organization chart, the latest released by the Army, shows Air Corps setup.



GENERALS OF THE AIR CORPS

John F. Curry

Gerald C. Brant

George C. Kenney

Barton K. Yount

Rush B. Lincoln

Walter R. Weaver

of workers. Expansion of activity has been hugely magnified, and the end is not in sight.

From thought of one airplane at a time or at most 10 airplanes at a time, the Air Corps has been plunged into the necessity for thinking in terms of thousands of airplanes at a time. With a production goal indicated of 50,000 airplanes a year, millions of dollars have been spent, millions more are being spent, and many millions more will be spent to satisfy the public demand for adequate national defense. It is the Air Corps' job to spend, intelligently, these millions, yes, these billions, and to see to it in the process that the American public gets a dollar value for every dollar expended.

Engineering, another major responsibility of the Air Corps, covers great territory in one word. It covers research and development of military aircraft. It covers passing upon the design, specifications and performance tests of military aircraft. It covers everything its mighty Materiel Division has been able to handle in the past and will be able to absorb in the future—and that is a very great deal. The Air Corps, among other matters, determines the Air Forces' requirements in equipment, facilities and other materiel supplied by other arms and services for installation in military aircraft.

It is not enough that the Army Air Corps provides the Combat Command with airplanes and equipment as good as that of other powers—the American public demands that it be better. In order that this demand may be satisfied, there must be and there is—endless research, endless testing. A military airplane is born fairly rapidly in these days of mass production. The travail came months, even years before, on the drawing board and in the research laboratory.

The B-19, the world's biggest bomber, is spectacular to the layman, and the men who fly it are justly entitled to the acclaim they receive. But the unsung heroes of the B-19 are those men whose minds conceived it, those men who patiently tested part after part far into the night, and night after night, and those hundreds of other men who did each his part to the level best of his ability that one day the B-19 might be flown and that millions of Americans might marvel.

The B-19 is used as an example because it symbolizes in form the youngest child readily can grasp the procurement and engineering efforts of the Army Air Corps. The Air Corps itself does not—cannot—regard the B-19 itself as a finished product; rather it regards the B-19 as a Wright field on wings, a flying laboratory for further testing.

To the Air Corps, the B-19 is only an indication of what the future will bring in the way of heavy bombing planes, capable of long-range operation at high altitudes and at high speed, carrying loads of terrific destructive potentialities. Remember this, when the B-19 roars overhead; the shadow of its batlike wings is a portent for the future.

Coming down to earth from the B-19 for a moment, the Air Corps is charged with the issuance of technical instructions. It provides the War Department with the basis for requirements of personnel, equipment and stores to be furnished to the Army Air Forces by other arms and services.

The Air Corps is responsible for all construction of flying fields under the 54-group program, which includes 54 combat groups and six transport groups.

Yes, and it prepares estimates for the Army Air Forces appropriations and such control and supervision of funds so appropriated, as may be delegated. It prepares plans governing construction of stations of the Army Air Forces. It establishes, operates and maintains schools and the allied facilities that are essential to them.

Among other matters, there will be eight very large $8,000,000 depots, at least three huge training establishments for pilot training, at least two very large activities for technical training.

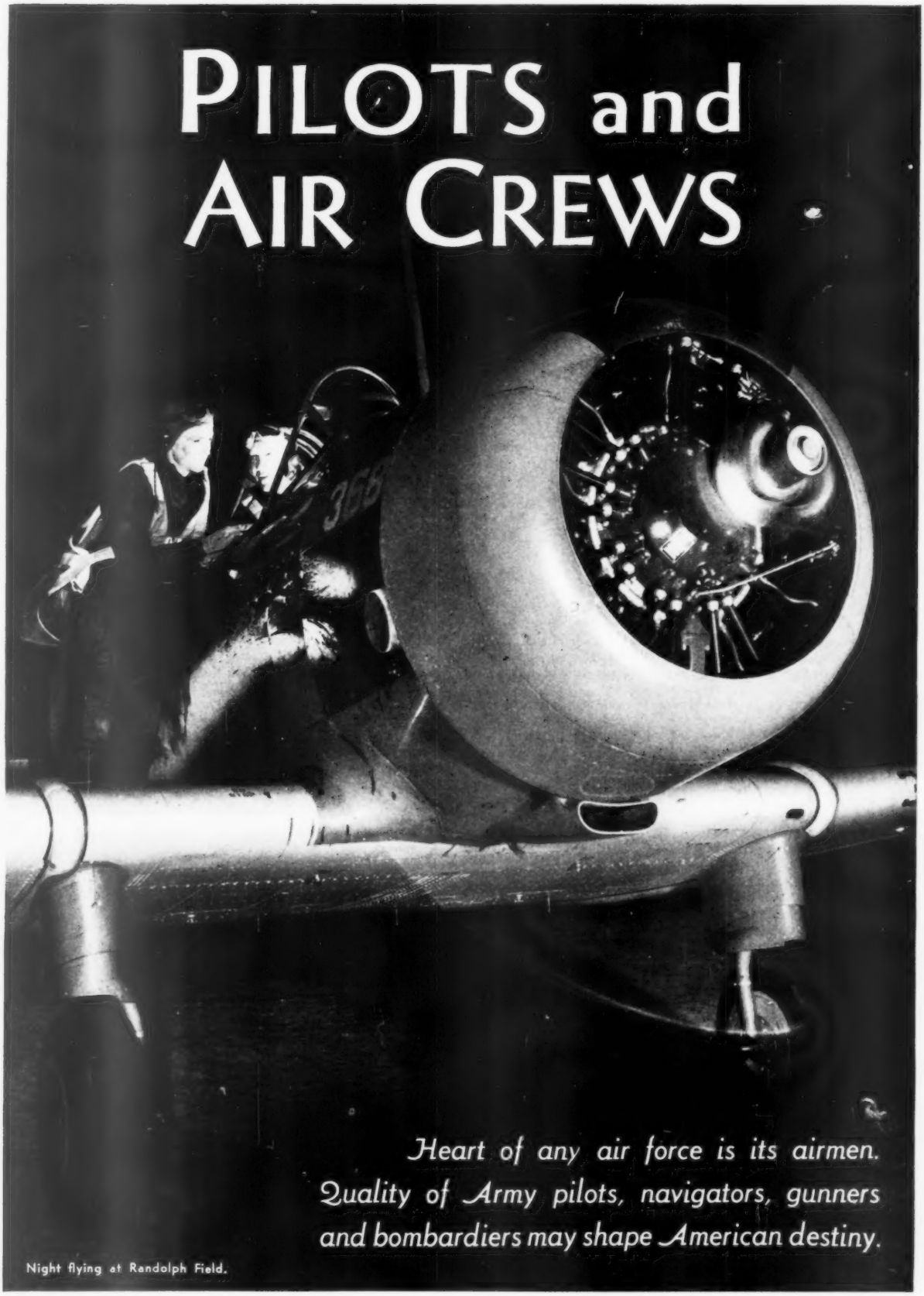
And in addition, it has command and control of all Air Corps stations and all personnel, units and installations, including station complement personnel and activities.

These are highlights of Air Corps responsibilities. Any of the major activities—training, procurement and supply, engineering, or construction—merits not merely an article to do it justice but a book of encyclopedia size. Suffice it to say in the short space afforded by the mechanical limitations of this particular article that the Air Corps has as many responsibilities, though on a huger scale, as a housewife.

That is perhaps why the Air Corps has been referred to as the "housekeeping" Corps unit of the Army Air Forces. Possibly that is reasonably correct terminology, because the Air Corps, like the housekeeper, has heavy responsibilities, endless work, and little enough glory.

(*Continued on page* 202)

PILOTS and AIR CREWS



Heart of any air force is its airmen. Quality of Army pilots, navigators, gunners and bombardiers may shape American destiny.

Night flying at Randolph Field.

PILOTS and AIR CREWS

by Brig. Gen. DAVENPORT JOHNSON

A West Pointer from Texas, Brigadier General Johnson left Infantry for military aviation in 1916. Rated a command pilot, he holds Silver Star and Purple Heart medals. Is expert in pilot training.

THIS fall the Army Air Corps will step up the training rate of military pilots from 12,000 to 30,000 a year. Behind this simple statement of a tremendous program lies, perhaps, the crux of our national defense effort in the air, for the backbone of airpower is not the airplane, but the combination of the pilot and the airplane. The airplane's value must be measured largely by the skill and training of the man at the controls.

Perhaps this illustration is simplified too much, particularly in the case of today's multi-place warplanes. They are something more than the combination of pilot and airplane—they are a combination of *air crew* plus airplane; the pilot becomes a unit in a team which must be highly trained, skilled and able to function together smoothly if the airplane, the squadron and the air force is to attain maximum efficiency. That is why, in addition to stepping up pilot training, the Air Corps at the same time is increasing the training rate of navigators, engineering officers, bombardiers, observers, radio operators, gunners and all the other members of the warplane team.

The training of radio operators and gunners is discussed elsewhere in this issue. Here we are concerned with how pilots and those air crew members who go through substantially the same type of airmanship program are developed from flying (recently renamed "aviation") cadets.

The first flying cadet class under the 30,000-pilot program is scheduled to enter elementary flying schools during the latter part of 1941. The 12,000-pilot-a-year rate was attained Mar. 22, 1941, when a class of 2,091 aviation cadets began 30 weeks' instruction.

Under the current 12,000-pilot program, 28 civilian contract flying schools are conducting the 10-weeks' elementary training period. Basic and advanced training is handled at 10 Army Air Corps schools located at Montgomery, Ala.; Maxwell Field, Ala.; Barksdale Field, La.; Eglin Field, Fla.; Randolph, Kelly and Brooks Fields, Tex.; San Angelo, Tex.; Moffett Field, Cal.; and Stockton, Cal.

Eleven more Army Air Corps flying schools are planned. Their sites are at Macon and Albany, Ga.; Selma, Ala.; Ellington Field, Tex.; Victoria, Tex.; Bakersfield and Taft, Cal.; Mather Field, Cal.; Phoenix, Ariz.; Las Vegas, Nev.; and Panama City, Fla. Additional civilian contract flying schools also will be selected, since War Department policy calls for maximum use of the civilian contract flying school system.

Plans for the 30,000-pilot program call for elementary training in 41 contract civilian flying schools, as compared with the present 28 schools under the 12,000-pilot program. Basic training is to be carried on in three contract civil flying schools and 15 military flying schools, instead of the present one and seven. Advanced training will be at seven military flying schools (single-engine) and 14 military flying schools (two-engine), as compared with the present three single-engine and eight two-engine military schools. There will be one basic-advanced military school for Negro pilots, as at present. Flexible gunnery training will be featured in five military schools; at present there are two. The Air Corps will operate four replacement centers (pilot, bombardier and navigator); at present there are three.

The maximum number of trainees at any one time is to be approximately as follows, the first number being the maximum under the 30,000-pilot program and the second that under the present 12,000-pilot program: Elementary training in contract civil flying schools: 9,730-4,050. Basic training in contract civil flying schools: 576-100. Basic training in military flying schools: 6,515-3,293. Advance single-engine training in military flying schools: 2,178-918. Advance two-engine training in military flying schools: 3,872-1,633. Bombardier training, enlisted men, in military flying schools: 950-660. Bombardier training, aviation cadets, in military flying schools: 660-440. Navigator training in military flying schools: 1,710-740. Navigator training in contract civil schools: 400-400. Aircraft observer training in military flying schools: 200-200. Flexible gunnery training for enlisted men in military flying schools: 2,800-1,600. Replacement centers, pilots, bombardiers and navigators: 8,228-2,400.

Between the raw youth who enters the primary training stage in a civil contract school and the trained pilot-officer who emerges 35 weeks later lies something like $25,000 worth of "processing." Cadets receive $75 per month base pay, plus food (or $1 per day subsistence allowance), uniforms, shelter, medical attention and the like. In addition, the Government provides $10,000 flight risk insurance during the training period. Reduced from the peace time year of training, this Air Corps processing has become highly concentrated without losing efficiency.

Another variation of the versatile North American formula is the AT-6 single-engined advance trainer.

One of the Army's first multi-engined advance trainers is the Beechcraft AT-7. This model is used for pilot training as well as in the training of navigators.

This is the modern pursuit pilot, each of whom costs the U. S. a fortune to train.

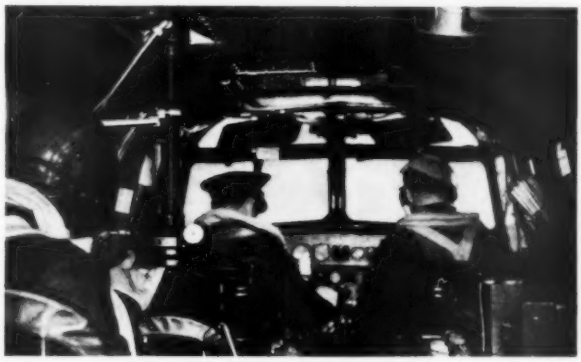
Badly needed navigators, formerly cadets, are being trained by Pan American Airways.

Also vitally important to the Army Air Forces are its bombardiers. These men are trained at Barksdale Field, La. Certain aviation cadets are eligible for course.

Rigid standards of military discipline, morale and training have been carried into the 28 civilian schools selected to give primary training under Army contract. At one of these schools, representative of the other 27, there now are two classes in training at all times, with a total of 425 cadets. The school operates three fields and, during 1941, this one contractor will put through 10 weeks of primary stage a total of eight times as many primary cadets as were processed at Randolph Field in any single year prior to opening of the expansion program.

A ratio of one instructor for each five students is maintained. At first only one airplane was available for every five cadets.

(*Continued on page* 140)



Streamlined Air Forces training now finds pilots and air crews working tactical flight problems together in advanced trainers.

Latest trainer is the Ryan PT-21, first low-wing monoplane to be accepted for Army primary training. A similar trainer is Fairchild PT-19.

Typical basic trainer is the Vultee BT-15. Aviation cadets advance from primary to basic, usually at Randolph Field.

GROUND CREWS

by Maj. JOSEPH L. LOUTZENHEISER

Born in Ohio, February 5, 1899, Major Loutzenheiser, a West Pointer, served in the Infantry and Quartermaster Corps before joining Air Forces in 1928. He holds senior pilot and corps observer ratings.

BEHIND each military airplane must stand a thoroughly trained, technical ground organization, or that airplane cannot long remain in operating condition. Training of ground crews, especially of aviation mechanics, therefore constitutes a major and vital phase of the Army Air Forces' expansion program.

The Army Air Forces' enlisted strength was increased under the National Defense Act, as amended in June, 1938, to 21,500. Another paragraph of the same act authorized the President to increase this number by 15 per cent, or 3,225, to a total of 24,725. The 1940 budget, however, provided for a total of but 19,046, leaving a shortage of 5,900 actually required to man the then existing goal of 2,320 airplanes.

The Air Corps in February, 1938, had but one organization for instructing technical and enlisted personnel, the Air Corps Technical School. It was then in process of division into two units, one for the parent base at Chanute Field, Rantoul, Ill., the second to be moved to a new school base at Lowry Field, Denver, Colo. The radio and armament courses were at that time slated for transfer from Chanute to Lowry Field to permit their enlargement. Mechanical courses were retained at Rantoul. An Act of Congress approved in August, 1937, provided that a 960-acre site for the Denver school be turned over to the Government, including buildings and land suitable for a gunnery and bombing range.

In addition to the 960-acre site, the Government acquired an area of 100 square miles (64,000 acres) east of Denver for a technical school, bombing and aerial machine-gunnery

Without skilled mechanics to maintain them, Randolph Field's vast fleet of trainers would be grounded.

They are called grease monkeys and pencil pushers, but the Army Air Forces, generals and all, would be in hopeless confusion without them.

range. The increasing quantity of aircraft and the new military planes' complexity and size, meanwhile, pushed up the need for technicians. These conditions imposed a burden too heavy to be borne by the technical school and resulted in a school expansion program which has continued since at an accelerating rate.

How many men will be required to keep in operation airplanes acquired in this emergency? That will depend on how many of these ships are to be kept in active operation and how many in reserve. For the total 5,500 airplanes proposed when the school expansion program began, the Air Forces estimated that 43,000 men would be needed, or about eight men per plane. This program, however, contemplated the holding of 2,163 of the airplanes in reserve, with 3,337 in regular operation. Air Forces figures called for about 10.1 men per active airplane.

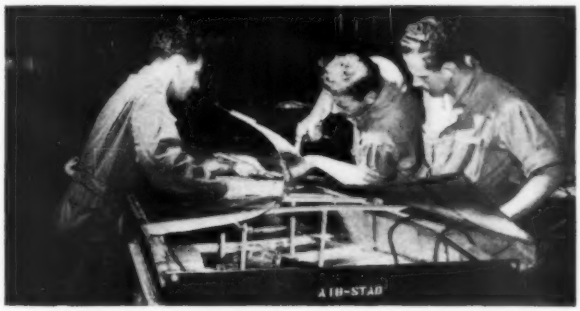
Overhaul of Air Forces aircraft is carried on at depots which, in the United States proper, are manned by civilian mechanics. Although no large-scale effort had been made to train apprentices for this work, there were about 100 in the Air Forces, providing a nucleus for training expansion when the emergency came. Air Forces civilian mechanics were coming from any source. In some cases, enlisted men—trained by the service—were leaving the service to go into depots as civilians. Other employes were graduates of commercial schools training airplane mechanics.

Approximately 65 per cent of Air Forces' enlisted men must be trained technicians of some specific type. Of the 25,000 enlisted men proposed at the emergency expansion's initiation, the Air Corps had to plan to train 16,250 as specialists. This initially large total, however, continued to grow as the program was amended upward. It soon became apparent the Chanute and Lowry Field schools were going to prove inadequate. As in its pilot training, the Air Corps was compelled to use civilian schools in addition to expanding its own training facilities. This technical training problem's immensity becomes apparent when the War Department's proposal to add 152,589 more men to the Air Forces and its supporting services during the 1942 fiscal year is considered. To this service must be attached officers and men from the Finance Department, the Quartermaster Corps, the Ordnance Department, the Signal Corps, the Chemical Warfare Service, the Adjutant General's Department, the Medical Department, the Corps of Chaplains and the like.

When the emergency began, the Air Corps Technical School were obtaining approximately 11 students from the ranks of Air Forces' enlisted men to one from civil life. The school annually was taking in about 100 high school graduates from an approved waiting list which, at the time of the emergency, had about 2,000 names. Recognizing the difficult training and personnel problems presented by the Air Forces' expansion program, the Secretary of War at that time ordered the consolidation of all such Air Corps training and personnel activities under the Chief of Air Corps. This is the foundation upon which the tremendous expansion of Air Corps technical training has been based.

On May 17, 1939, the War Department announced these civilian schools would train 1,000 Air Forces' enlisted men: Curtiss-Wright Technical Institute of Aeronautics, Grand Central Air Terminal, Glendale, Cal.; The Aeronautical University, Inc., 1330 South Michigan Avenue, Chicago; Roosevelt Field, Inc., Roosevelt Field, No. 1, Mineola, Long Island, N. Y.; Spar-

Included on ground crews' roster are clerical workers such as these two Finance Department staff sergeants at Randolph Field.



Two embryo grease monkeys learn correct riveting technique. The Air Forces' repair men must be practically able to build planes.

Ground workers above, assisted by civilians, handle Army books. Below: Keeping planes spick and span is another ground crew job.

One of the most important of many ground jobs is that of the flight dispatcher. These Mitchel Field men, mostly enlisted, are part of the organization that must function to keep warplanes flying.

tan School of Aeronautics, Tulsa, Okla.; Casey Jones School of Aeronautics, Inc., Newark, N.J.; New England Aircraft School, Boston, Mass.; Parks Air College, Inc., Parks Airport, East St. Louis, Ill.

These schools were to augment the Chanute and Lowry Field service schools. The Air Corps also established a basic technical training school at Scott Field, Ill., for basic training of selected Air Forces' soldiers before sending them to Chanute or Lowry, or to one of the civilian schools. The plan was to send the 1,000 enlisted men to civilian schools between July 1, 1939, and June 30, 1940, while Chanute and Lowry Fields were being expanded. The civilian schools were to give training only in airplane mechanics, or the operation, maintenance and minor repair of planes and engines, so that students might qualify as mechanics upon graduation. Radio operation, photography, armament and other special technical courses were to be Army schools projects.

"Such procedure will aid the Army while present Army schools are being expanded to peak production and will also test these schools' suitability for training the thousands of airplane mechanics required by the Air Corps in an emergency," explained then-Secretary of War Harry H. Woodring. "If this test shows civilian mechanic schools can turn out satisfactory Air Corps mechanics, as the War Department believes they can, they will constitute a very effective part of our national defense organization."

In September, 1940, the War Department awarded contracts to Aircraft Industries Corporation, Glendale, Cal., and the Casey Jones School of Aeronautics, for the training of specialized technicians. The contracts, part of the expanding plan to increase the number of technicians training in civilian schools, were in addition to the earlier contracts for training airplane and engine mechanics. The Glendale school was to teach sheet metal fabrication to 392 regular Army men from August, 1940, to June 30, 1941. The Casey Jones school was to instruct 42 soldiers in aircraft welding during the same period.

On April 24, 1940, the War Department announced further training expansion at the Air Corps Technical School's Chanute Field branch to provide for enlisted men's instruction as weather observers and weather forecasters. The school was a consolidation of the weather observers' course established at Scott Field in August, 1939, and the weather forecasters' school, set up at Patterson Field, Fairfield, O., in August, 1937.

Observers had been taking a four months' course and forecasters a six months' course. With the schools' consolidation, the observers' course was extended to five months and the forecasters' to nine months. Later, as procedure improved, the courses were shortened to 12 weeks for observers and 26 weeks for forecasters.

Illustrative of the civilian school plan's success, the War Department on Aug. 21, 1940, awarded $10,893,248.94 worth of contracts to civilian schools training pilots and mechanics. Contracts also were being negotiated with other schools. This made possible doubling the number of mechanics in civilian schools. Allotment of students to them was increased from 1,500 to 3,448. No new schools were added to the original list.

Early in 1941 the Air Corps established a course for former

(*Continued on page* 180)

COLOR PHOTOGRAPHY

On the following six pages we present a selection of the outstanding color photographs in aviation.

Due to the special nature of this issue, the editors of LIFE have graciously granted us prior rights to publish several of these pictures, originally scheduled for LIFE magazine.

Hans

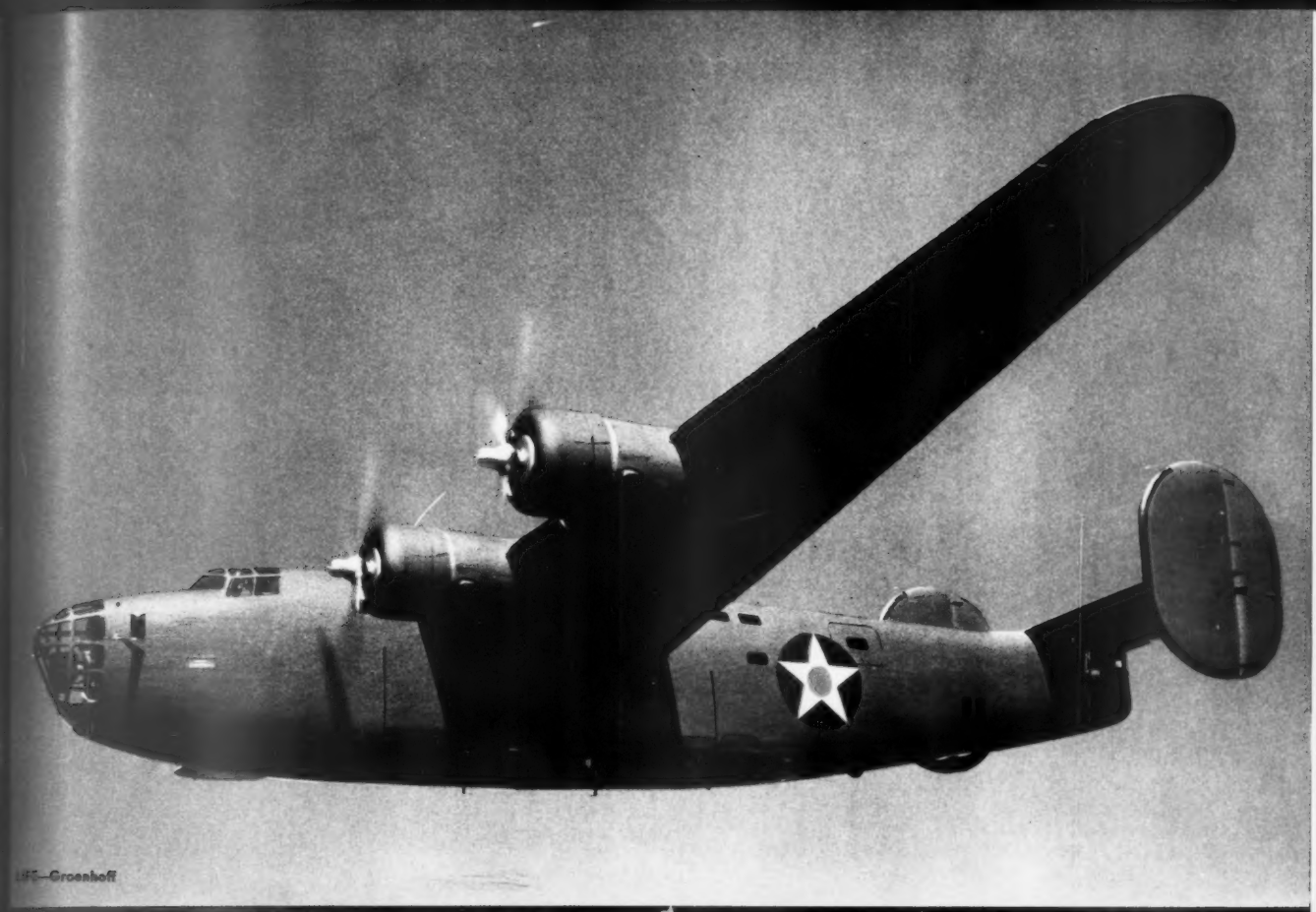
Hans Groenhoff

MAJOR GENERAL HENRY H. ARNOLD

Deputy Chief of Staff for Air and Chief of the Army Air Forces

First modern long-range American bomber was the Boeing B-17. Its latest modification is the B-17D.

One of the Army's deadliest new bombers is the Martin B-26. It is shown below without warpaint.



LIFE—Groenhoff

Spearhead of Air Corps long-range attack, with Boeing B-17D, will be the new Consolidated B-24A.

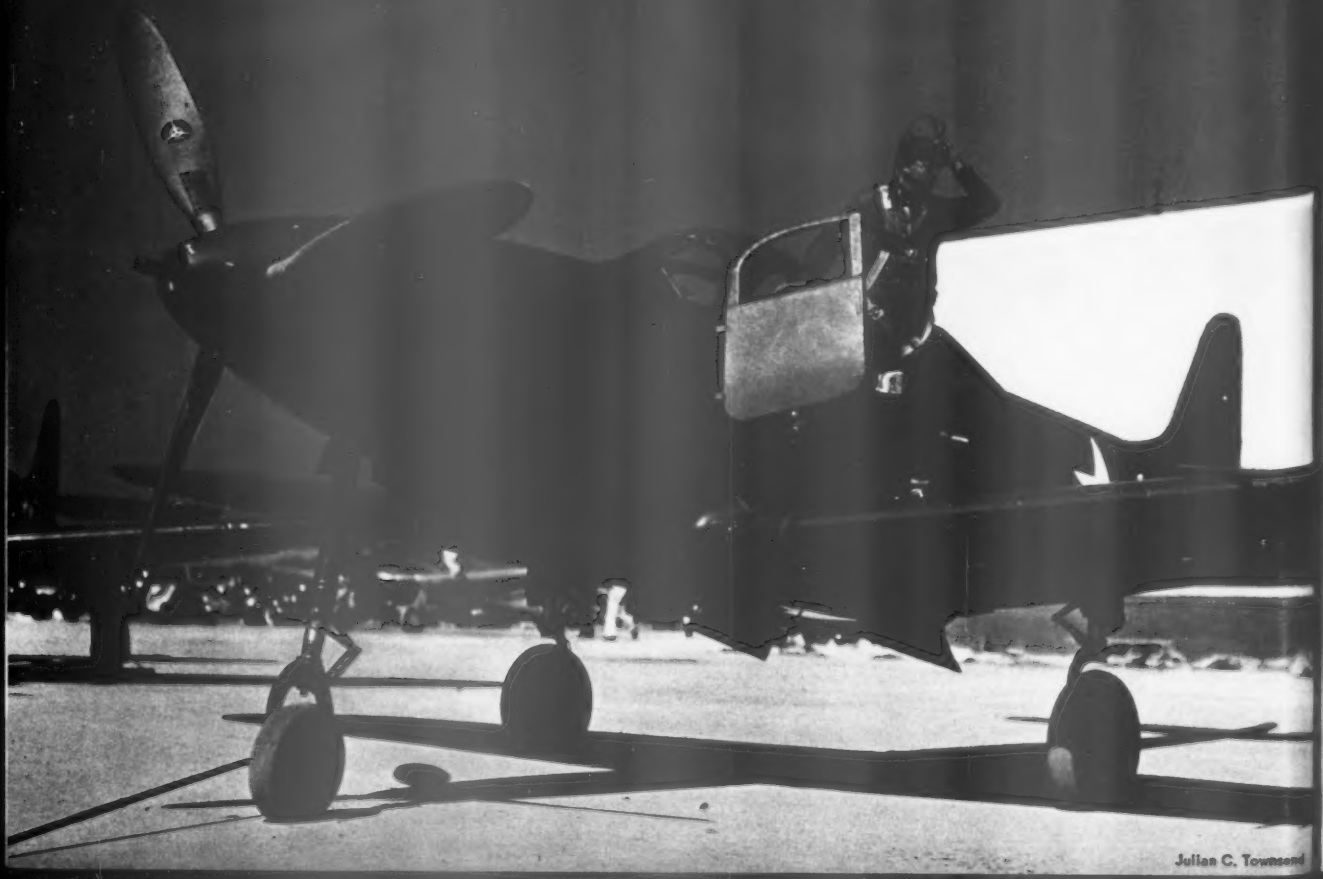
Though it bears the old Army attack designation, the Douglas A-20A is a fast, short-range bomber.

LIFE—Groenhoff

Rudy Arnold

North American, already represented in almost all Air Corps categories, now produces B-25 bomber.

Bell P-39 is one of few Army types without flight restrictions. Gun in propeller hub is 37mm. cannon.



Julian C. Townsend

Rudy

Staple Air Force pursuit is the Allison-powered P-40, now being supplanted by the newest P-40D.

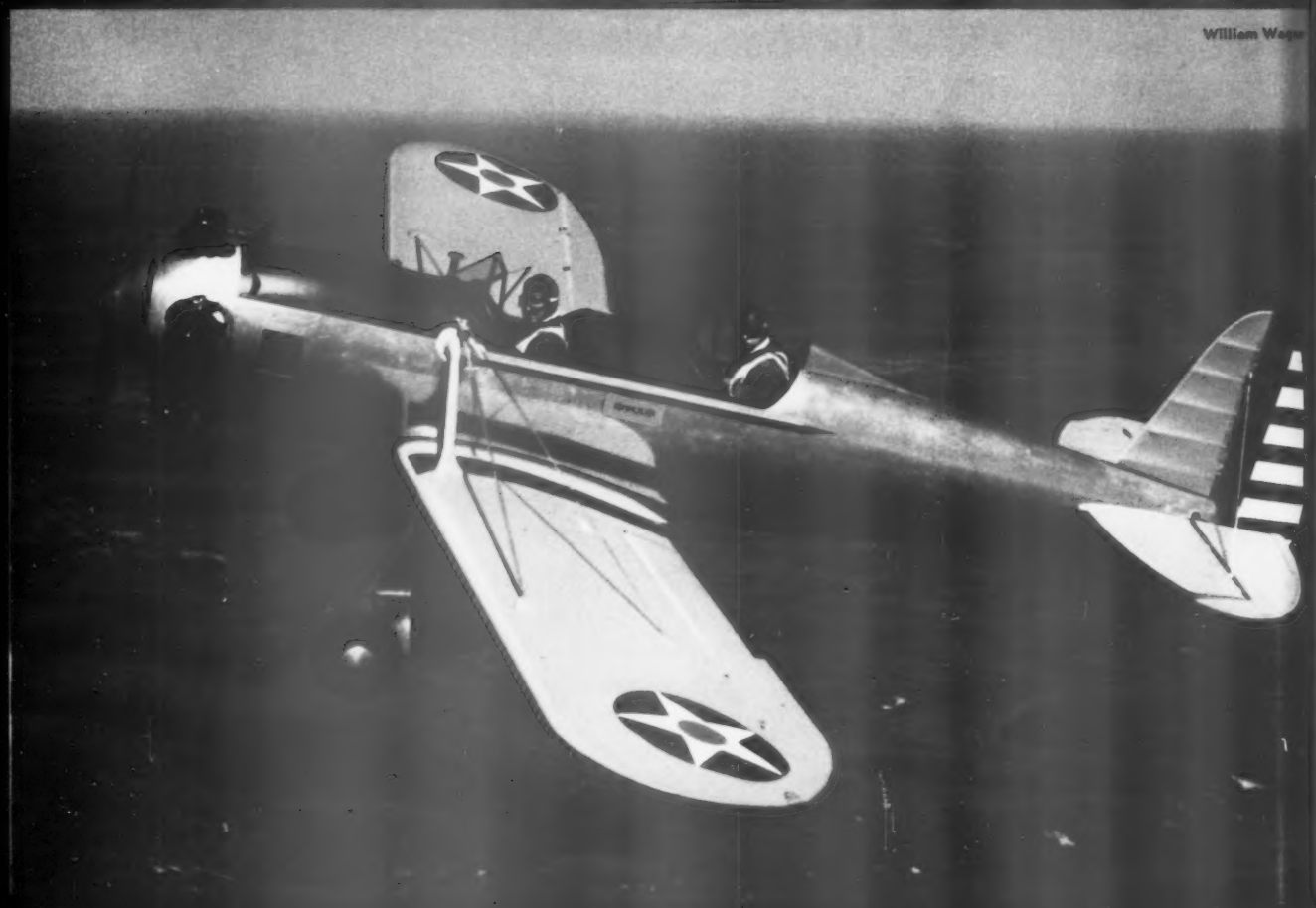
Probably best-liked among pursuit pilots was the P-36, shown below with out-dated Army markings.

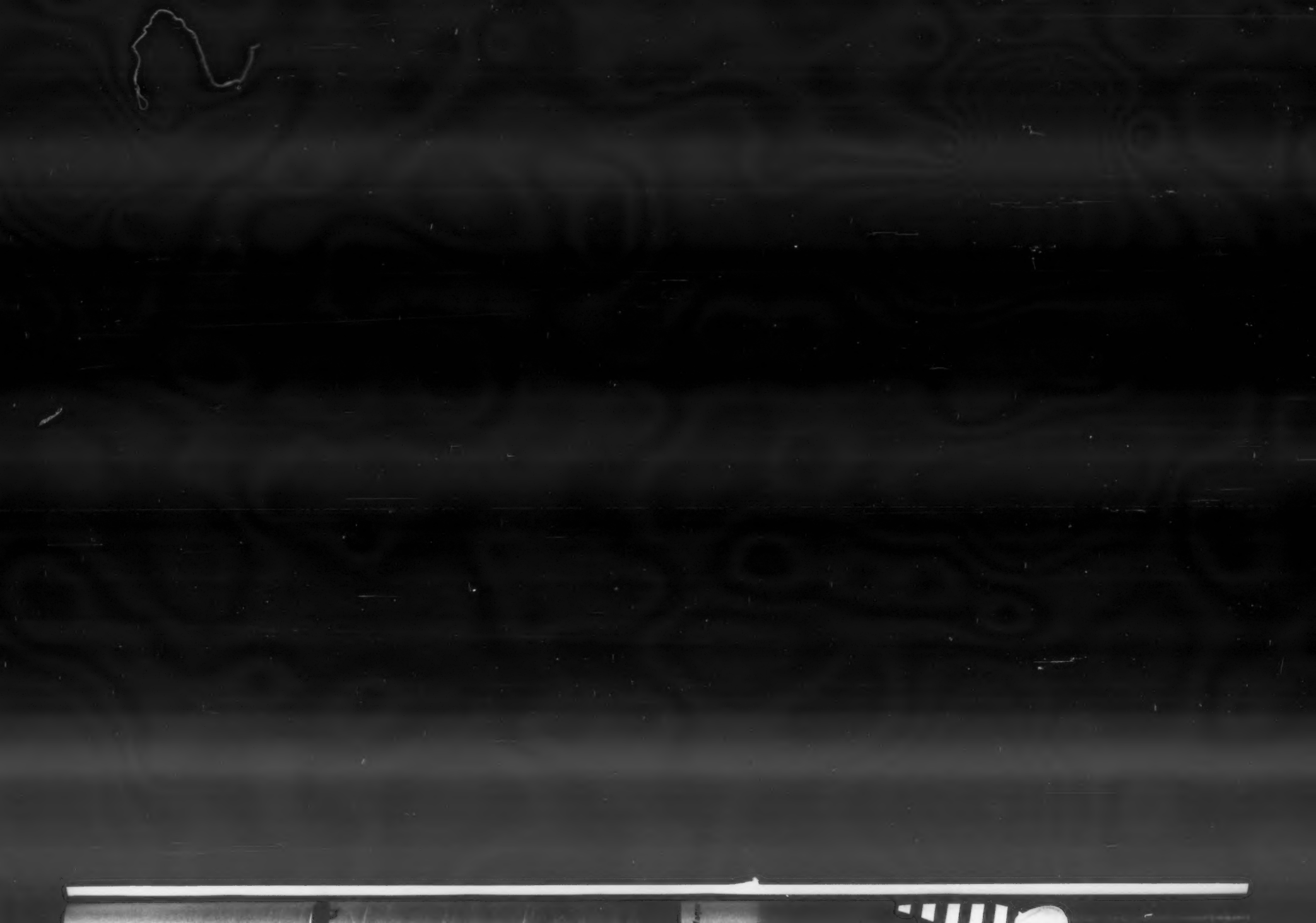
Rudy Arnold

Latest observation plane, the Curtiss O-52, has slots, flaps, retractable wheels, little armament.

Among newest Army primary trainers is Ryan PT-21. Black paint in front of windshields cuts sun glare.

William Wage





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THE WORLD'S "Fightingest" BOMBER

IS BREAKING PRODUCTION RECORDS, TOO

Facts on the performance of this great ship are secret. But—

SPEED? The Army says its new Martin B-26 medium bomber is "faster than many pursuit planes now fighting in Europe."

BOMBS? Nearly double the capacity of its nearest American competitor, giving it "striking power unequalled in a medium bomber."

DEFENSE? Fire power from numerous gun positions firing in every direction, making it the most heavily defended airplane of its class.

TURRETS? Yes, large guns in a tail turret for rear defense, and Martin's power-operated twin-gun turret for defense in the upper hemisphere.

BULLET-PROOF FUEL TANKS? The B-26 carries its entire fuel supply in the latest development—Martin's "Self-Sealing Mareng Cells."

ARMOR? All Martin fighting ships carry armor for the pilots and gunners—protection for our skilled crews in combat.

Great airplanes like the B-26 do not "just happen." They grow from years of study, research, experiment, "planning for the future."

The B-26 started as a U. S. Army "Type Specification"—a set of tactical requirements growing out of intensive study of what the airplane of the future would have to do in aerial combat.

To this Martin added a quarter century of bombardment experience—a quarter century that saw the Martin Star and Circle proudly displayed on the world's most famous bombers; the Martin MB-2's of 1918-28, the Martin BM-1's of 1929-32, and the Martin B-10's of 1933-39—all airplanes that had set new world standards for bombardment performance.

From this foundation Martin not only conceived, designed and built the B-26, but with it tools and fixtures for manufacturing it efficiently, economically, in quantity.

As a result, the B-26 is being produced in formidable numbers now—on mass-production equipment more complete in its operation and more simplified in its usage than America has developed heretofore.

No, great accomplishments like the new B-26, or like Martin's swiftly multiplying facilities for mass-production, do not "just happen." Just as they are the fruits of experienced planning, so Martin airliners of the future—beneficiaries of today's great defense-time developments—will grow from seasoned study of the needs of the happier commerce of a world at peace.

THE GLENN L. MARTIN COMPANY, BALTIMORE, MD., U. S. A.

DEFENSE IS ON THE WING! *Huge new Martin Patrol Bombers for the U. S. Navy (below), as well as Bombers for Britain's R. A. F., are coming from Martin assembly lines in numbers never before equalled in the production of large military aircraft.*

Martin
AIRCRAFT

BUILDERS OF DEPENDABLE TRADE MARK AIRCRAFT SINCE 1909

MATERIEL DIVISION

This is the organization that literally "keeps 'em flying", supplying bases with a bolt or a whole plane.

by Maj. Gen.
O. P. ECHOLS

General Echols, Chief of the Materiel Division, is an ex-major of Field Artillery who decided to switch to the Air Service. He transferred in 1920, and has earned renown as a pilot.

THE Materiel Division is the Army Air Forces' insurance that its aircraft and equipment are the best men can produce at the existing developmental stage. It is the organization which searches out solutions to aviation's unsolved practical problems, then sees that Uncle Sam's air armada benefits by these discoveries without delay.

Purpose of the Materiel Division is to have in readiness for immediate production and service the most advanced types of aircraft, engines, armament and other equipment for the nation's defense; to procure this equipment in necessary amounts; to issue it to the various Air Forces tactical organizations and to maintain it properly throughout its serviceable life. Laboratories to aid in carrying out this purpose at present contain nearly $35,000,000 worth of equipment.

The Material Division operates under a chief, stationed in Washington, D. C., and responsible to the Chief of the Air Corps. Policies are determined in Washington, then referred to the Materiel Division headquarters at Wright Field, Dayton, O., nerve center of Air Forces research. The chief cooperates closely with the chief of the newly-organized Maintenance Command, another unit with headquarters at Wright Field. He also has supervision over the great air depots at Fairfield, O.; Middletown, Pa.; Sacramento, Cal.; San Antonio, Tex.; Ogden, Utah; Mobile, Ala.; and new depots now being organized; three procurement districts, centered at Inglewood, Cal., Wright Field and New York City; and six industrial planning districts, based at New York City, Buffalo, Cleveland, Detroit, Chicago and Los Angeles.

Genesis of today's Materiel Division was the War Department's decision in October, 1917, to set up an engineering laboratory at Dayton. Named McCook Field, after Gen. Anson McCook, a Civil War officer, the new unit was established as the Airplane Engineering Department, Signal Corps' Equipment Division. Its object was aeronautical experiment, testing and research, in order to develop adequate aviation equipment for wartime purposes. Construction was started Nov. 5, 1917, with Lieut. Col. V. E. Clark, Signal Corps, in command. Throughout the war it did much valuable work. Later its name was changed to Engineering Division, Air Service, U.S. Army. By Jan. 1, 1919, McCook Field had a 254-acre landing area and 69 buildings, including hangars, shops, laboratories, offices, hospital and a wind tunnel. Personnel consisted of 56 officers, 322 enlisted men and 1,096 civilians.

In 1926, on recommendation of the Morrow Board, the Air Service became the Air Corps. Engineering Division functions were broadened to include supply, procurement and maintenance of all Army aircraft. Again the name was changed, this time to the Materiel Division, its present title.

Despite McCook Field's world-acclaimed work, it became obvious that an even larger experimental aeronautical research laboratory was needed. In order to keep the Army's air center in Dayton, home of the Wright brothers, the community raised $425,000 to buy 4,500 acres of land lying about 5½ miles east of the city. This was given to the Government as a permanent home for the Materiel Division. Officially opened on Columbus Day, 1927, today it stands, greatly expanded, as Wright Field, Materiel Division.

At present there are approximately 5,000 civilian employees at the field and more coming daily. More than 350 officers—ranging in rank from second lieutenants to a brigadier general—are stationed here. At nearby Patterson Field, Fairfield, O., are another 150 officers and 3,500 civilians. Under pressure of a new wartime emergency, giant hangars and new laboratory buildings have sprung up at both almost overnight. One project includes a giant wind tunnel valued at more than $3,000,000 and said to be the largest of its kind in the world.

The Materiel Division's two major activities are engineering and procurement. Detailed descriptions of the work of these units and their components appear in the following articles in this issue. Briefly, however, Engineering directs research, while Procurement handles supply purchasing.

The Engineering phase is split into two main bodies: Experimental Engineering Section and Production Engineering Section. These are further subdivided into five chief branches: Aircraft, Power Plant, Equipment, Materiels and Armament. Numerous smaller units—the propeller laboratory, aircraft radio laboratory, photographic, etc.—are devoted to intensive study of various important problems.

Procurement is responsible for purchasing practically all equipment and supplies used by the Air Forces, a job which now runs into billions of dollars each year. It maintains district inspection officers throughout the country and has jurisdiction over officers who serve as Air Forces representatives at aircraft manufacturing plants.

Many branches and sections are duplicated at air depots throughout the United States and its possessions. But each is under the control of Materiel Division officers responsible to their chief in Washington.

Wright Field's Field Service Section—now a part of the Maintenance Command—is responsible for the adequate flow of supplies to Air Forces units at home and abroad, as well as the proper maintenance of these supplies.

During its 20 years' existence the Materiel Division has figured—directly or indirectly—in every aircraft development, commercial or military. McCook Field experiments in 1919 produced the famous Wright *Whirlwind* engine, first of the air-cooled radials. Development of superchargers was another pioneering venture of these engineers. Materiel Division experts' work, in cooperation with the petroleum industry, raised the octane rating of aviation fuel from 50 to 100, increasing both airplane speeds and safety.

The sextant and the earth inductor compass which played such an important part in early trans-oceanic flights were first applied to aircraft here. The first solo blind landing and the first automatic landing were accomplished by Division men. The first night airway system in the United States—between Columbus, O., and McCook Field—was established and flown by Division pilots.

The Engineering Section was responsible for the transition from wood to metal propellers, as well as for metal propeller improvements, such as the incorporation of controlled pitch full feathering mechanism. Substitution of Prestone for water

(*Continued on page* 168)

EXPERIMENTAL

Automatic movie recording unit now is used by flight test branch instead of old knee-pad on which test pilot had to write notes.

Chief of Experimental Engineering's flight test branch is Maj. Stanley Umstead, who flew the B-19 on its recent maiden flight.

by Lieut. Col.
FRANKLIN O. CARROLL

Indiana-born, Lieutenant Colonel Carroll is one of Army's best engineers. A graduate of Illinois University and the Mass. Inst. Tech., he joined the Air Service in 1918 after two years as Cavalry officer.

This Wright Field branch is the test tube of Army aviation. All new equipment goes through it.

"THREE years ahead of the procession," that's the goal of Wright Field's Experimental Engineering Section, which continuously plans new planes and new aircraft equipment to supersede the best we have today. Other Wright Field engineers refer to it as the "Buck Rogers" section because of the radically new and unorthodox designs which frequently are tested. But new ideas must prove themselves against technical knowledge of past experiments and tests, compiled in 23 years of continuous Air Corps research at Wright Field and its predecessor, McCook Field.

The new designs are not new in the sense of being out and out inventions. Rather, they are developments, using the best of accepted designs as a concrete working basis. The result will be a new airplane which can fly farther, or faster, or carry more load, than present planes of the same class.

The mammoth Douglas B-19, with 212-foot wingspread, now getting its first tests, can trace its parenthood back to the Boeing B-15, a bomber with a 150-foot wing span which, in turn, is one step in size and range beyond the first four-motored monoplane bombers, the Boeing B-17 *Flying Fortresses*, with 100-foot wingspread. Before the B-19 has barely gotten its wheels off the ground, the Experimental Engineering Section is hard at work on newer bombers.

A new warplane may be born in the minds of staff officers at Washington or in tactical service. They foresee the need for aircraft with certain range, speed and load requirements. Long-range bombers, interceptor pursuits, photographic and observation ships, slow planes for communications work, ambulance planes and various training planes—all are being redesigned and improved continuously to meet changing conditions.

Air Corps specifications leave very little to the designer's imagination regarding the plane's general type and purpose, but urge him to employ his utmost ingenuity on design details. He is, moreover, encouraged and assisted to make his airplane the world's best of its type. Specifications include requirements of structural strength, stability and maneuverability, materials, ease of production and accessibility to maintenance, as well as performance.

The "idea men" must take care not to demand more than is possible of the designer. The aircraft engine is one of design's limiting factors. For example, the B-19 is powered with 2,000 h.p. engines, which had not yet been developed back when the B-15 was designed. A plane of the size, range and speed of the B-19 was impossible to produce until engines of sufficient power were available. Yet even today, the B-19 is underpowered.

Specifications finally completed, the Air Corps invites manufacturers to submit designs based on the specifications set forth, with offers for building such planes in various quan-

ENGINEERING

Pilots' assignment board in flight test branch shows wide variety of airplane types test pilots must fly. Note list of ships ranging from primary trainers through pursuit and bombardment planes.

tities ranging from one experimental article up into thousands of ships. A set of three-view drawings showing as much detail as possible is received from each manufacturer. From these, scale models are constructed for wind tunnel testing.

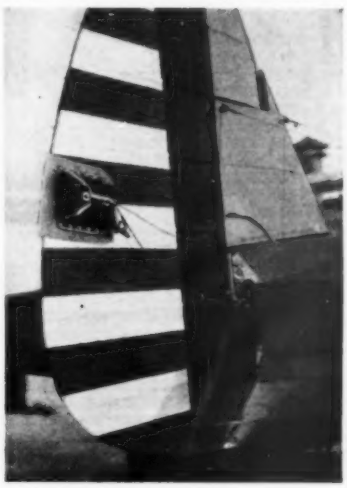
Frequently the models are brought to Wright Field for testing. Sometimes they are tested in the manufacturers' own tunnel, or that of some university or the National Advisory Committee for Aeronautics. In any case, the procedures are similar. The smooth-surfaced miniature airplane is suspended by a system of wires within a big metal tube and subjected to high speed blasts of artificial wind produced by huge fans. Accurate measuring equipment records the efficiency of the model's aerodynamic design, in terms of its performance in the tunnel.

Work is being completed at Wright Field on a huge new wind tunnel with a test chamber 20 feet in diameter, in which models with wingspread up to 16 feet may be tested in wind-speeds up to 400 m.p.h. Its 40,000 h.p. electric motor, which turns two of the 16-bladed fans, is said to be the largest ever built. The tunnel is considered the world's largest. Because of the size of the models it will accommodate and the high speeds possible, this new tunnel is expected to provide far more accurate data on various aerodynamical problems than has been possible heretofore.

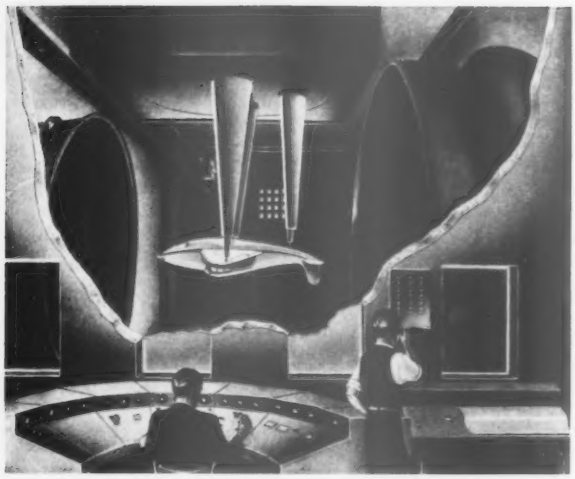
Advantages of wind tunnel tests are obvious. Various fuselage shapes, airplanes designed as pushers (with the propellers behind the engines) in comparison with the more conventional tractor designs, placements of the wing, streamlining of engine nacelles, engine cooling arrangements—all may be compared and tested in the wind tunnel before planes are constructed. When the model has completed its wind tunnel tests, its designers can tell, with only a small percentage of error, the airplane's top speed and much other performance data, before actual construction of the full-sized plane begins.

The designers make still another check on efficiency of equipment placement, crew and armament within the plane, by constructing a full sized "mock-up," or model of the craft, in which they can place the various articles of equipment, or dummies of the same size. Until recently the builders made their mock-ups of wood, with a cloth covering to simulate the aluminum alloy "skin" of an all-metal airplane. With the industry's growth, some manufacturers now are building metal mock-ups so that the model resembles the finished plane much more closely and can be used as an accurate reference model for the actual airplane's construction.

Small parachute whips plane out of spin in case of test-flight mishap.



The mock-up test often uncovers a change in structural design which must be made to prevent interference with necessary functions of the ship. Wright Field engineers say that wind tunnel and mock-up tests together have saved many thousands of

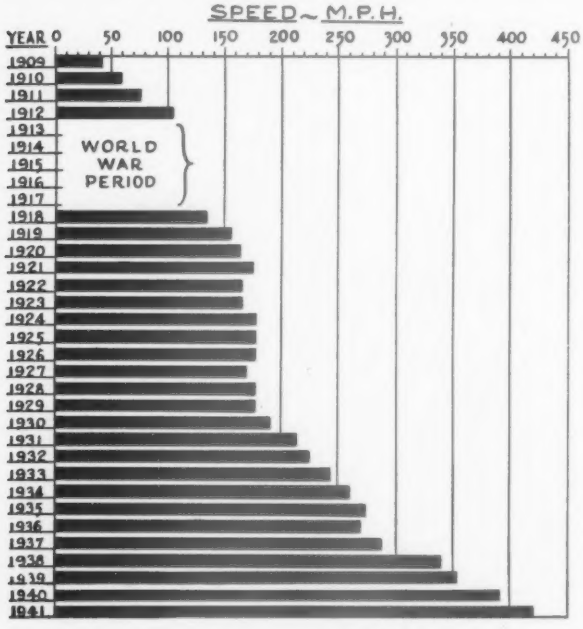


New 400 m.p.h. wind tunnel now being completed at Wright Field will broaden scope of Experimental Engineering test branches.

dollars in construction costs by uncovering errors in aerodynamic design, or in placement of equipment and personnel. Had these errors gone undiscovered until the actual airplanes were built great cost and delay would have resulted.

To speed up production of new models the Air Corps has departed from its usual practice to order planes "right off the drafting boards" without requiring submission of a single prototype plane in advance. This practice obtains, however, only where the manufacturer has built satisfactory planes of the same general type previously or where the design has been thoroughly proven by wind tunnel tests and other preliminary checks. Under the new plan, Wright Field takes delivery on an early production model of the new design and "puts it through the wringer" while mass production on additional planes of the same model continues.

Wright Field tests of new aircraft may be classified generally as structural and flight tests, although the two overlap and are coordinated. Structural testing involves piling huge weights in the fuselage and on wings to determine whether they are capable of carrying the tremendous loads which will be imposed on them in flight maneuvers. More recently the



Army plane speeds since 1909.

structures test engineers have achieved the same effect, more accurately, by an hydraulic suction device which can exert a suction force equivalent to any desired load on any part of a plane.

Ability of the landing gear to absorb shock is determined by drop tests. Tires and wheels, too, must demonstrate their strength under drop tests. Brakes are tested on special flywheel machines which develop great rotational speed and then are brought to a dead stop. Vibration tests are widely used on airplane structures, control surfaces, instruments and equipment installed throughout the plane. It is essential that all of these articles avoid vibration frequencies which might lead to a destructive shaking of the airplane, or any part of it.

Often a fuselage or wing of new design is purposely tested past its destruction point in order to find its ultimate strength. Perhaps the structure is built too strongly and can be lightened, saving valuable pounds, which will add to the airplane's performance. Or perhaps the structure will exhibit a weak point with various stresses and strains, which must be corrected before the design as a whole can be approved.

The experimental engineering testing program also involves research and experiments with all types of materials used in fabricating airplanes and equipment, as well as with various manufacturing processes which may speed up production.

Experimental wings, and even complete airplanes, are purchased for tests to determine the relative efficiency of plywood, stainless steel, magnesium alloy and other materials. Spotwelding and various riveting methods are tested to develop time-saving methods which may be introduced into industry.

Special attention has been directed recently toward developing synthetic or substitute materials for Air Force equipment, to replace those difficult to obtain in wartime. Outstanding in this work has been production of nylon fabrics and other synthetic silk materials to be substituted for real silk in parachutes and for use in corded tires. Cotton materials are proving satisfactory substitutes for linen webbing used in parachute harness. A synthetic fabric is now under development to replace present fabric covering for control surfaces.

Of vital importance in the defense program is Wright Field's development of camouflage paints, used on our newest warplanes to provide them with dull, non-reflecting coats of "protective coloration".

Propeller blades, too, come in for coats of non-glare paints and lacquers, usually dull red or black. The silvery disc of a rapidly revolving propeller reflects sunlight or searchlight just as does the silvery wing or belly of a plane. Painting of the propeller serves another purpose, too. The effect of ground lights in a night landing, when striking a propeller not treated against reflections, is to shine a fiery red disc into the pilot's eyes, adding considerably to his landing hazards.

To permit an air force to operate efficiently in the field, a wide variety of devices is necessary for rapid servicing and maintenance. Development of these also falls to Wright Field's experimental engineering laboratory technicians and engineers. Huge truck fueling units, crash trucks, mobile field repair outfits capable of handling major repairs, small machine shop trailers for minor repairs, maintenance stands for mechanics, jacks for hoisting bombers for servicing tires or landing gear, airplane tarpaulins to protect against frost and ice, engine heaters, gasoline generator units, portable field lighting equipment, portable steel mats which can convert soggy fields into usable runways—all these and many other articles are being developed and tested for eventual distribution by the Field Service Section (see the Maintenance Command article elsewhere in this issue).

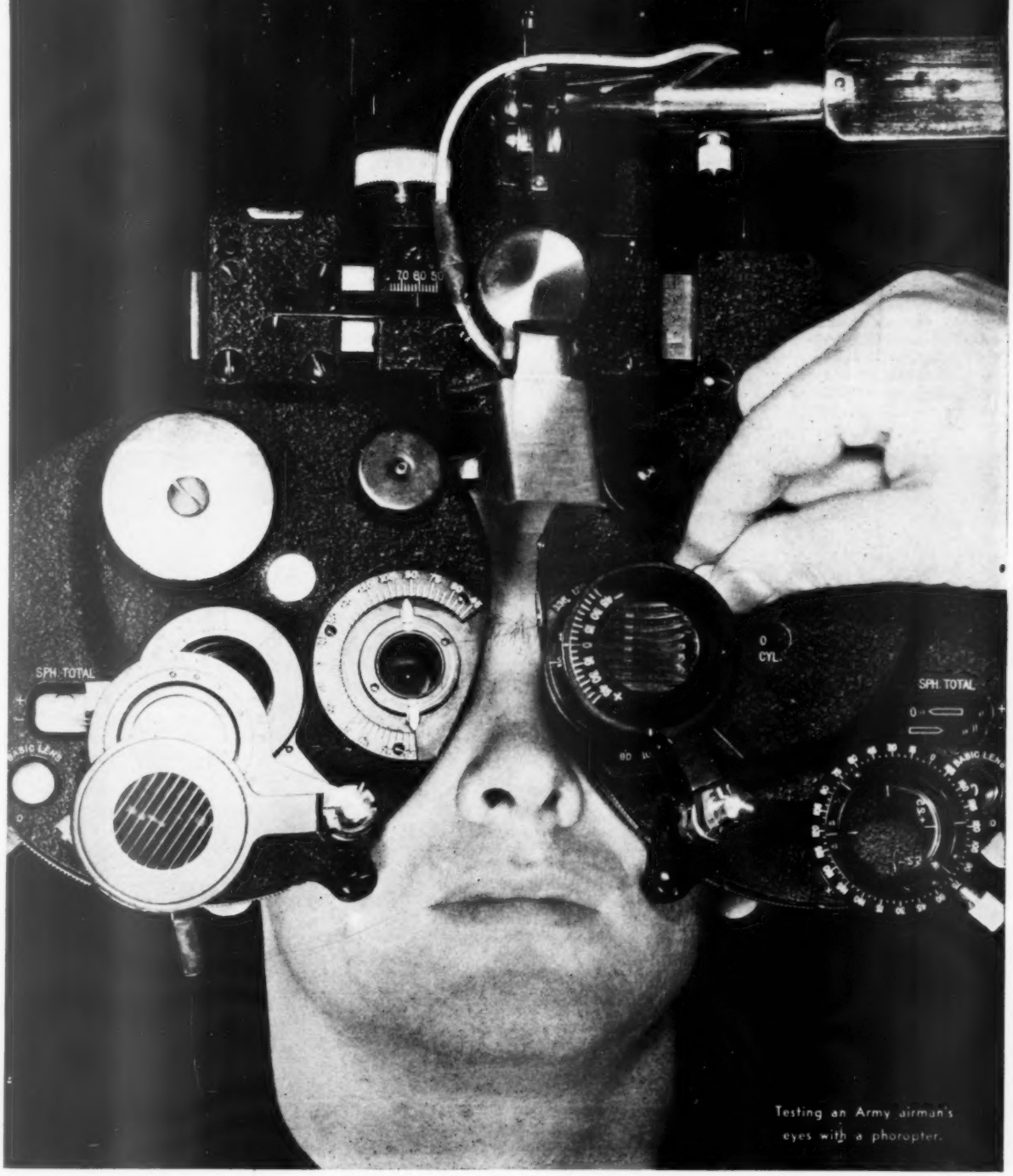
Since experimental engineering includes in its scope the entire research and development program at Wright Field, the section chief—Lieut. Col. F. O. Carroll—also supervises the work of a number of other laboratories. Among these are the photographic laboratory, the aero medical research laboratory, the instrument-navigation and aircraft-radio laboratories, the engine and propeller laboratories, and the armament laboratory, all of which are described elsewhere in this issue.

Returning to our newly-designed airplane which has completed its structures tests, we find that it has been re-assembled and is ready for its flight tests. These are a series of gruelling

(Continued on page 208)

AERO MEDICAL

Cardinal purpose of Air Corps medical men is to anticipate and prepare for increased physical demands on Army flyers.



Testing an Army airman's eyes with a phoropter.

AERO MEDICAL

by Maj. OTIS O. BENSON, Jr.

Now 39, Major Benson is a graduate of two leading U. S. medical schools. Until recently he was chief of Aero Medical Section, Wright Field. He is in London observing RAF pilot's reaction to combat.

THE question: "How much can an airman stand?" has not yet been answered. Research into the human body's strange quirks under the punishment of altitude, extreme speed, lack of oxygen, centrifugal force and intense cold is one way of answering that question. That research, together with physical and medical safeguards surrounding the Air Force pilot, is the province of the Aero Medical Laboratory, Wright Field, Dayton, O. Currently emphasized by Laboratory physicians are pilot fatigue, blackouts resulting from zooming climbs, effects of gases and engine fumes and, above all, how to solve the problem of the terminal velocity dive.

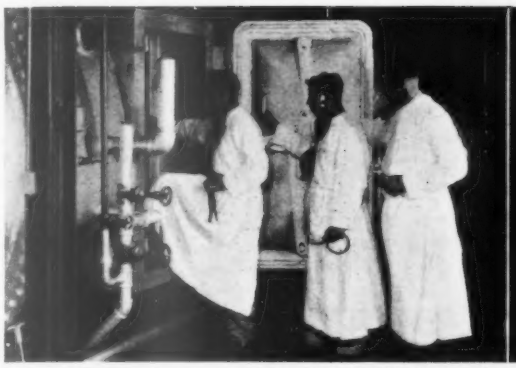
For years Army flight surgeons have been airmen's guardian angels. The doctors tell the pilot when he is fit to fly and when safety requires that he stay on the ground. They have developed oxygen equipment to keep him alive at altitudes where he would die without it. They have waged war against little bubbles of nitrogen creeping into the blood stream during violent climbs and power dives. Doctors have designed electrically-heated clothing and other articles which permit a human being to operate today's high-performance airplanes without losing his life.

Since its establishment at Wright Field in 1935, the Aero Medical Laboratory has come to represent the ultimate authority in physiotherapy, medical practices and preventative methods in the field of aviation medicine. Its fame is international. Its director, Maj. Harry G. Armstrong, last year was named co-winner of the Collier Trophy (with the other scientists who collaborated with him in solving high-altitude flight problems). He now is in England studying with, and advising, the RAF on the same topic.

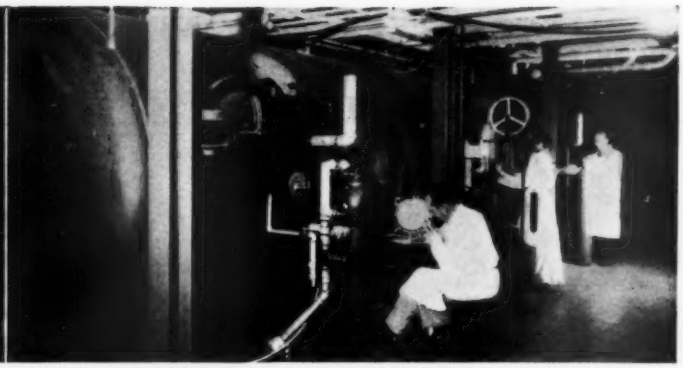
In his absence the laboratory continues its experiments and its development of new aero medical practices under the direction of Maj. D. B. Dill, a reserve flight surgeon borrowed from the Harvard "fatigue" laboratory. Major Dill is assisted by Dr. J. W. Heim, veteran civilian lab chief.

The Laboratory is a professional forum organized somewhat like a permanent convention of the Army's flight surgeons. Groups of them are arriving at Wright Field con-

An Air Force doctor tests a Randolph Field cadet for high altitude oxygen starvation on "rebreather."



Two volunteers above are entering Aero Medical's famed pressure chamber for simulated high-altitude experiment.



Altitudes up to 80,000 feet can be duplicated in the pressure chamber. Maj. Harry W. Armstrong, famed altitude research pioneer, sits in the foreground.

tinuously, leaving again after a few days or a week. During their stays they are given technical demonstrations of the new equipment developed at the laboratory and are instructed in the latest techniques authorized for personnel treatment. In small groups over a period of five weeks, more than 100 pilots and flight surgeons recently received instruction in the use of new oxygen equipment and new types of protective clothing for high altitudes, and an intensive course in the human body's physiological reactions at extreme altitude.

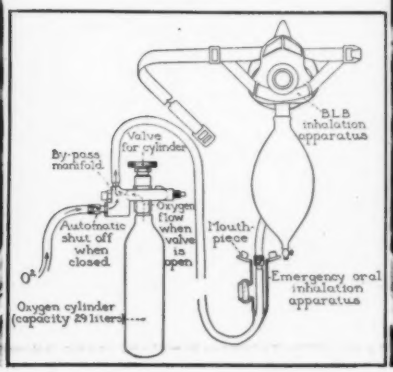
Present research is directed into three main channels: protection of air crews against anoxia (lack of sufficient oxygen), aeroembolism (formation of nitrous bubbles in the bloodstream), and paralyzing cold. To assist the scientists in their experiments, the laboratory has designed and installed intricate apparatus reproducing the exact conditions of any point in the upper air. Employing Air Corps volunteers, the doctors are able to study the human body's reactions to diminishing oxygen, terrific sub-zero temperatures, or sudden changes in direction which produce centrifugal forces so violent that the subject often faints. The sight of strong men falling to the floor of test chambers is a daily occurrence at the laboratory. Some of these volunteers offer their services because they have a scientific curiosity about their own physical limits; others merely because they want to help the work along. One such human "guinea pig," Pvt. Raymond Whitney, was awarded the Distinguished Flying Cross for offering himself as a laboratory subject in the high-altitude test tank and in the XC-35 airplane which led the way to today's pressurized-cabin airliners.

These laboratory test tanks are about the same diameter as a big bomber's fuselage, but shorter. Volunteers enter them, doors are locked and the scientists peer through thick glass windows from the outside. Then, depending upon the experiment's nature, the air is pumped out, or the temperature is lowered to some figure like 65° below zero, or the interior is filled with noxious gases representing engine exhaust fumes. In other types of test tanks a man might be whirled suddenly from a sitting position upside down, at a force five to eight times that of gravity, and the centrifugal force on his seat belt measured in pounds. If he faints, the test is stopped and he is carried out.

From data tabulated during these experiments, the Aero Medical Laboratory has discovered that a pilot in excellent health and with a superb physique can stand a pull-out force of five G's without fainting. It has been learned that if he will thrust his body forward at the moment of pull-out until his head is down between his knees, he can stand eight G's. A special chair was designed for planes which must execute high-speed dives. The chair absorbs some of the strain and eases the tendency toward "blackout," or temporary faints during the instant of pull-out.

The laboratory has been largely responsible for the success of the new-type oxygen masks now worn by all Air Forces altitude air crews. This mask replaces the older pipe-and-mouthpiece device, which was more expensive and required heavier tanks and more piping in the plane's interior. Known as the BLB mask—named for Drs. Boothby, Lovelace and Bulbulian of the Mayo Clinic, who developed it—the mask now is equipped with an emergency flask and tube. The flask is carried in the knee pocket of the airman's flying suit. If

Developed jointly by Mayo Clinic experts and Aero Medical men, the BLB oxygen mask (left and below) has replaced unsatisfactory old oxygen system. Photograph at right shows emergency usage of mouthpiece when mask is not available. BLB stands for Mayo Drs. Boothby, Lovelace and Bulbulian.



he is forced to take to his parachute at modern aerial warfare's extreme altitudes (30,000 to 35,000 feet), the flask will keep him alive until the parachute reaches the safe levels close to the earth.

Another great step forward in pilot protection is the laboratory's "decompression" technique, which protects pilots of fast interceptors capable of climbing a mile a minute, or diving at equal speed. The sudden change in atmospheric pressure produces in the pilot's body a condition known as aeroembolism, the same disease which divers call "the bends." Tiny nitrogen bubbles in the blood stream collect at joints and in large arteries, producing temporary paralysis and frequently serious injury. The laboratory has devised a procedure whereby the pilot who is to fly one of these super-speed interceptors exercises on a gymnasium bicycle for 30 minutes prior to the flight, while wearing an oxygen mask. This substitutes pure oxygen for the nitrogen in the blood and guards him against such seizures. He then may climb and dive safely at terminal velocities.

Protective clothing experiments have produced heavy leather and fleece-lined garments which will keep an airman from freezing at medium altitudes (up to 25,000 feet), but which, science has learned, will not give complete protection above that level. For extreme altitudes it has been necessary to design electrically-heated garments, including gloves and boots. Bombers are not airliners. They cannot afford the weight of pressurized-cabin equipment capable of maintaining constant interior temperatures and pressures. They are pierced with numerous flexible gun-ports around which air will escape; they have huge bomb-bay doors which must be opened. Consequently, a military plane's interior temperature and pressure must be the same as that outside. Devising clothing suitable to withstand temperatures which sometimes reach 67° below zero is a problem the laboratory must solve.

This Randolph Field cadet is undergoing heart tests while flying from sea level to 10,000 feet. Device is electrocardiograph.

Another pressing problem originating during a laboratory experiment has been turned over to the Materiel Division. It is the purely mechanical difficulty of developing a design which will allow oxygen piping to be installed in the cabins of bombers and other high-altitude craft. This piping must have special outlets where the crew can plug in their mask lines. This will eliminate the present clumsy procedure of dragging long oxygen hose lines whenever a crew member must change position inside a large plane.

Other test chambers check the fitness of pilots and air crews assigned to high-altitude flights. If the operations office decides that an airplane must climb to 32,000 feet, for example, to test engines or propellers or cameras, the crew selected for the flight is placed in these chambers and subjected to a loss of pressure equivalent to that altitude. If they faint, they fall over on the floor of a test chamber and not in the cabin of an altitude plane, where a pilot's collapse might cause a crash. If certified as fit, the operations office knows there is no danger of interruption aloft from personnel causes.

Developing apparatus and techniques for physical examinations in all branches of Army flying is an important Aero Medical Laboratory task. In the altitude tank, for example, volunteers often are subjected to loss of oxygen equal to a rate of climb of 3,000 feet per minute, to 10,000 feet without a pause. There are halts at 10,000, 15,000 and 20,000 feet and finally at 24,000 feet to check the subjects' pulses. Frequent faints from "anoxia" above 15,000 feet are the rule, but a few whiffs of oxygen usually bring the subject back to consciousness. A pilot who might operate without any oxygen on a short flight to 20,000 feet will "black out" on a long flight at 15,000 feet. This tank has shown, also, that oxygen equipment functioned at 38,000 feet. This experiment was proven in an actual flight in a Boeing B-17 to 34,000 feet.

A 10- to 15-minute supply of oxygen is carried on high-altitude flights, in a small cylinder which the airman carries in the knee pocket of his flying suit. It allows a safe descent from 40,000 feet by parachute with enough oxygen to keep the airman alive until lower levels are reached.

Experiments in the pressure tank have demonstrated that, while the normal atmospheric pressure on a human body at sea level is 14.7 pounds per square inch, at 34,000 feet the pressure is only a quarter of that, or 3.7 pounds per square inch. This loss of pressure contributes to the dreaded "bends" (aeroembolism) which is another major subject of the laboratory's work.

As long as a pilot is protected by windshields and cabins, the air inside the plane moves with it. The effect of speed on the human system is another new field for research. It is known that every inhabitant of the earth is moving through space at the rate of 12.4 miles per second, as the earth revolves. We do not notice that because the earth's atmosphere revolves with it. But when an airplane is removed from contact with the earth, physical forces come into play which make its speed very dangerous. High mortality among dive-bomber pilots in German *Stukas* forced the development of wing-flaps which reduced the diving speed to a safe 279 m.p.h. Unlimited diving speed, resulting in pull-out forces of five G's and above, cannot be borne by a human body for more than three seconds. Means must be found to protect the pilot's body against draining of blood from the brain and unconsciousness. If he could lie down in a prone position, he might fight off this tendency toward "blacking out." But this is virtually impossible in present-day planes.

Experiments along this line were conducted in the Army's XC-35 stratosphere pressure-cabin plane, and in the gondola of the *Explorer II*, the balloon in which Captains A. W. Stevens and Orval Anderson ascended to a record-breaking 72,395 feet in 1935. In the balloon gondola, a mixture of liquid oxygen and nitrogen was released to provide 27 cubic feet of pure oxygen per hour at a pressure of nine pounds per square inch, equivalent to 13,000 feet altitude, was maintained during the flight.

During that flight, solar heat maintained an interior temperature in the gondola varying from 10.4 degrees F. to 43.7 degrees F. Exterior temperatures dropped from zero F. at 16,700 feet to a minimum of 81 degrees below zero F. at 68,000 feet. Much valuable data was recorded.

All of this equipment, both in the laboratory and in experimental airplanes and balloons, shows how energetically the laboratory handles its responsibility. The laboratory was set up as clearing-house of professional and technical information for Air Force flight surgeons. From that purely service beginning, it has grown and expanded until today the laboratory holds jurisdiction over flight surgeons and aero medical practice throughout the Army. It establishes tests given applicants for appointment as flying cadet throughout the field of civilian medicine. It leads the medical profession toward a better understanding of the physical, medical and psychological problems arising when normal human beings

(*Continued on page 216*)

ARMAMENT

Any military airplane is only as good as its punch. U.S. Army aircraft machine guns, bombs and cannon can deliver the world's deadliest punch.

A R M A M E N T

by Maj. FRANKLIN C. WOLFE

Holder of the D.F.C., Major Wolfe was born in Colorado, Oct. 4, 1902. He joined Army Aviation in 1925. Graduate of Air Corps Technical School, he is rated senior pilot and is chief, Wright Field Armament section.

THE war abroad has necessitated rearming American-built fighting planes, bringing about changes in design to allow heavier armament—more and heavier caliber guns, hydraulic and electrically-operated gun turrets for bombers, leak-proof gasoline tanks and added armor plating. These factors are vitally important in increasing planes' combat effectiveness. Getting these improvements onto our warplanes and doing the job quickly has created a difficult problem for Army Air Forces' armament experts and the Ordnance Department.

Working together, Wright Field's Armament Laboratory, of the Experimental Engineering Section, Air Corps Materiel Division, and the Army's Ordnance Department are producing results that make American fighting planes among the most formidably-armed aircraft in the world.

Armed aircraft date back to the early days at College Park, Maryland in 1909 when the Wright brothers were training America's first military aviators—among them Maj. Gen. Henry H. Arnold, today Chief of the U.S. Army Air Forces. Here, the first machine gun was carried on an airplane and fired at a ground target. Crudely fashioned bombs were carried aloft and dropped. During the U.S. Army's campaign against Villa in 1916, the first-known incident of aerial bombardment took place when pilots with an U.S. Air Service squadron sent to the Texas border made a bomb from a tin can filled with explosives and dropped on the outlaw bands in their hideouts. These were the first known incidents of arming the airplane for combat purposes.

Progressive steps in making the airplane an effective military weapon were made during the World War period. Both Germans and Allies introduced new methods of equipping their fighting planes with machine guns and bombs. As early as 1915 German observers, flying over Paris, fired rifle shots at French aircraft they encountered. The French retaliated by giving pilots rifles and revolvers. These were not very effective, but they produced the first aerial combats. Later, machine guns, some mounted on the wing and shooting over the propeller, and others located at various positions on the airplane were introduced. These soon were synchronized to fire through the propeller and, from then on, Germans and Allies both increased the fire power of their aircraft. The French used the first cannon, a 37 mm. Hotchkiss, on the Voisin airplane. Guynemer, the French ace, used a similar cannon, firing through the propeller shaft of a Hisso engine in his Spad airplane. It proved effective against balloons and other aircraft. Leak-proof gasoline tanks and armor-plating also were introduced during this period but they came too late; the war was over before much could be done about their practical application.

Records of these experiments which took place during the World War were shelved in War Department files until recent years when the current war has brought them out again.

Today U.S. fighting planes are being equipped with the latest armament features: the Bell *Airacuda* utilizes two 37 mm. cannon mounted in its two engine nacelles. Both the Bell *Airacobra* (P-39) and Lockheed P-38 mount cannon and .30 and .50 caliber machine guns. In addition, U.S. medium and heavy bombers now are utilizing hydraulic and electric gun turrets mounting .50 caliber guns.

Problems concerned with putting these features on our fighting planes are many. Chiefly they are the worries of the Armament Laboratory. But engineers in the Armament Laboratory rely on the cooperation they get from the Army Ordnance Department, which controls all U.S. arsenals and furnishes bullets, shells, bombs and guns that are installed on the airplanes.

The Armament Laboratory is divided into several units, all under the Experimental Engineering section. These include the Bombing, Fire Control, Specifications, Service Liaison and Photo units. The Fire Control Unit is divided into two sections, one for flexible guns, the other for fixed. Each unit has its own separate function.

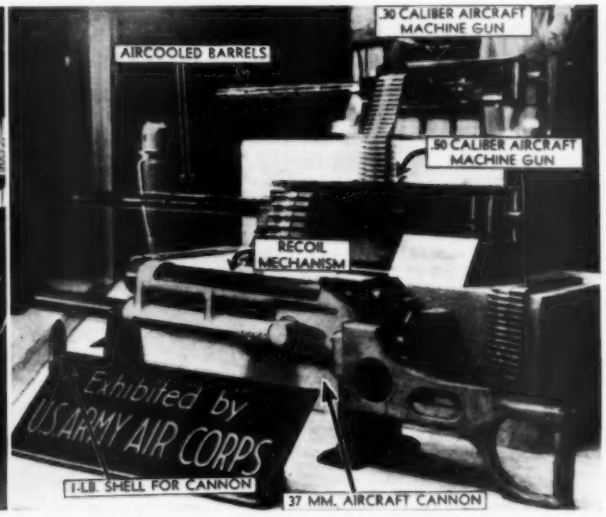
The Bombing Unit develops bomb sights, racks, releases and all mechanisms pertaining to the installation of such equipment in airplanes. Engineers of this unit also are charged with obtaining the bombs themselves from the Ordnance Department.

Propped up to show newsmen the effectiveness of its armament, this P-40 is firing its four .30 caliber and two .50's at range targets.

Close-up of Curtiss P-40 during fire-power tests shows how empty .50 caliber shells (arrows) are ejected from gun box.

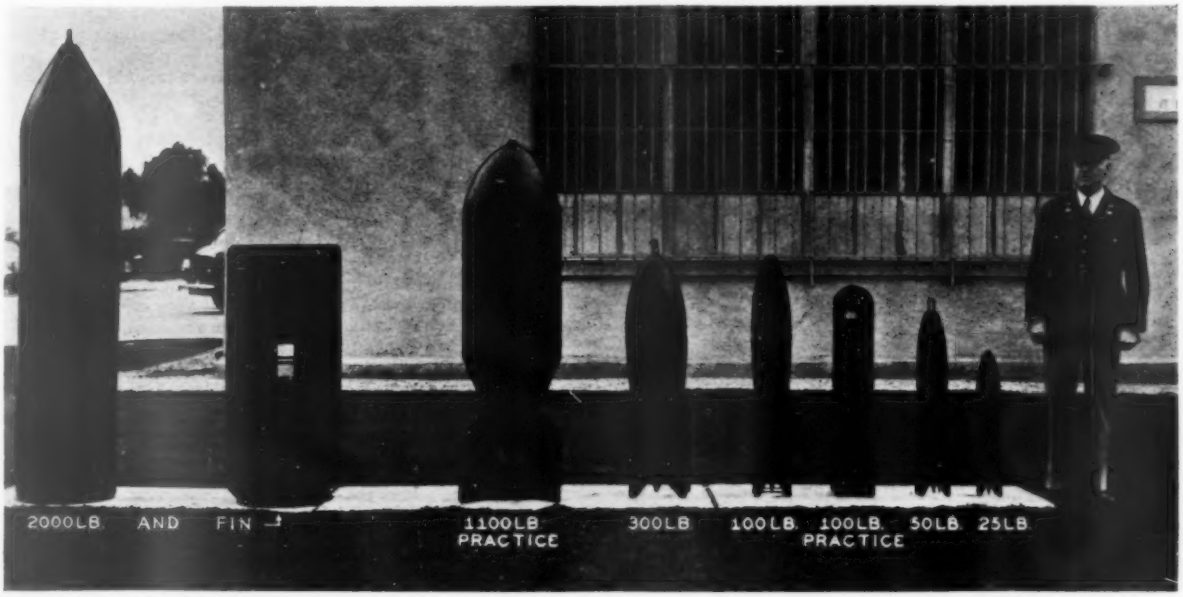
These fragmentation bombs weigh from 100 to 300 pounds each. Bombers use them against movements of troops, seldom for heavy targets. Bomb bursts before it strikes, scattering shrapnel for yards.

For practice bombing the Army uses these bombs which contain little powder, no shrapnel and are built of very light metals.


.30 CALIBER AIRCRAFT MACHINE GUN
AIRCOOLED BARRELS
.50 CALIBER AIRCRAFT MACHINE GUN
RECOIL MECHANISM
Exhibited by U.S. ARMY AIR CORPS
1-LB. SHELL FOR CANNON
37 MM. AIRCRAFT CANNON

These are four types of guns used on U. S. planes. Smaller .30 caliber gun (top) soon will be replaced by heavy .50 caliber.

Bombs used by the Army Air Forces vary in size from 25 to 2,000 pounds. Army Ordnance furnishes them to tactical units, but special armament section designs racks, releases and installs them in planes.



This gun, under repair, is a .50 caliber Browning. It fires 1,000 armor-piercing shells per minute. Gun in foreground is .30 caliber.

Armament Section engineers are responsible for developing highly important bomb sights. The above is one obsolete type.

One of many inventions exchanged between U. S. and British air forces is the R.A.F. power-driven turret, now on Army bombers.

Our Air Forces use two types of bombs—fragmentation and demolition. These may weigh anywhere from 17 to 2,000 pounds (the largest now being used). They range in price from $25 to $5,000. The type bomb used and its weight depend entirely upon the nature of its objective.

The fragmentation bomb, which seldom weighs more than 500 pounds, is used on missions aimed at ground troops or supply movements. These bombs are timed so that they explode several hundred feet in the air scattering shrapnel over a large area. Some, however, do not explode until they strike the ground or some other object. They contain sufficient powder to blow the shell to pieces and scatter the heavy metals —but not as much of the explosives as the demolition bombs.

Demolition bombs weigh between 100 and 2,000 pounds. As the name implies, this bomb is for demolishing an objective. There are three kinds: armor-piercing, semiarmor-piercing and general purpose. The armor-piercing bomb is used against objectives like a battleship, which has heavy 16-inch armor to protect it. These generally are in the 1,000- to 2,000-pound category. Smaller demolition bombs are used against factories, supply trains, ammunition dumps. They carry a great amount of explosives. Testing and installing these bombs in the airplanes is one of the tasks facing the Bombing Unit.

There are two methods of releasing bombs from aircraft today; the Bombing Unit developed both. By means of electrically-controlled selective panels, a bombardier can release bombs one at a time or in salvo. Bombs now are carried inside bombers, doing away with the idea of hanging them underneath the fuselage or wings. Racks have been designed that serve as "cradles" for the bombs inside the bombers' fuselages. This helps lessen drag and increases bombers' speed.

Another development of the Bombing Unit is the bomb sight. The Army has created some of the most accurate sights in the United States. Coordinating—by means of delicate and intricate instruments—speed, trajectory, wind velocity and other important factors such as weight, shape, size, American bomb sights are considered the world's best. The development of these sights accounts for U.S. Air Forces' relying chiefly on precision bombing.

Working with the Photo Unit, Bombing Unit engineers also have designed flash flare bombs which produce light equivalent to more than 7,000,000,000 candle power for night photographic work. The flare is working so effectively that cameramen are making night pictures as good as daylight pictures, thus changing the whole of military operations. (See the article on photography on page 98.)

Guns for bombers and fighters are the responsibility of the Fire Control Unit. The creation of revolving gun turrets, as used by the British so effectively to defend their bombers, has caused the Fire Control Unit to study both fixed guns that go on fighters and flexible guns that go in turrets.

There are three companies in the U.S. today making armor-plated, glass-enclosed turrets for U.S. bombers. The turrets are equipped with special sights and have mounts for as many as four heavy machine guns. Those which are located underneath the fuselage telescope outward so that guns are fired from almost any angle. Special design of turrets, application of guns and installation on aircraft have been developed by the Flexible Gun Unit of the Fire Control organization.

Fixed guns are those mounted on fighter planes generally in the nose or wings. All machine guns are .30 and .50 caliber Brownings.

The .30 and .50 caliber guns fire about 1,000 rounds per minute. Quick bursts have been found very effective in combat. Fighters are being designed to carry about 1,500 rounds per loading. Planes using cannon carry several hundred rounds per loading.

One of the most difficult problems facing the Fire Control Unit is shell ejection. Used shells must be ejected from guns as rapidly as they are fired. Engineers have designed various methods, still are working to perfect new ones.

On one experimental type airplane the shells were ejected falling directly into the backwash of the propeller and were thrown against the ship's elevator surfaces, ripping them apart and interrupting control. Such experiences are all part of the experimental program of the Fire Control Unit.

Nose guns and wing guns on U.S. fighters are fired in-

(*Continued on page* 214)

RADIO

Without radio the military airplane would be a comparatively helpless auxiliary to land forces.

Army traffic control operators.

RADIO

by Maj. GEORGE V. HOLLOMAN

For his work in perfecting Army's radio landing system, Major Holloman received D.F.C. in 1939. An infantry officer in 1925, he joined Air Corps in 1928. He helps direct Wright Field radio tests.

MODERN air war demands fighting planes which can take off for—and reach—any designated point, regardless of rain, snow, or fog. That today's ships can meet this challenge, day or night, winter or summer, largely is due to radio and allied navigational aids, many of them developed by our Army itself at its two Wright Field units devoted to developing and testing aircraft radio equipment and other instruments.

Larger of these is the Signal Corps aircraft laboratory, which has worked with the Air Corps in this field since the days of McCook Field, predecessor to Wright Field. First Army aircraft radio research centered at Ft. Monmouth, N. J., during the World War era. A pioneer Signal Corps group there experimented with radio installations in the rickety planes flown from the famous College Park, Md., field. Original installation, veterans believe, was made in a French plane about 1914.

World War wireless usage was confined almost entirely to transmitting signals from plane to ground receiving station. Reliable reception aloft was almost impossible, due to interference set up by the plane's ignition, charging generators and vibrating metal parts. The ground crew communicated with the ships by flares, cloth panels and the like.

Soon after the war, McCook Field Signal Corps engineers discovered they could eliminate interference with shielding and bonding. Radio telephony came into general use and soon Army planes had two-way communication systems. Cooperative development has continued down to the present, new commercial improvements being adapted to military aircrafts' peculiar needs.

Two main Wright Field laboratory units, Air Navigation and Communications, handle radio development. Other subordinate units assist them. The Air Navigation Unit is charged with research on radio navigation aids—radio compasses, ground radio range stations and other similar equipment, and instrument landing developments. The communications unit's objectives are improved radio receivers, transmitters and antennas for planes and ground airport stations.

Recent experiments by this laboratory aimed at discovering how different kinds of antennas work on different airplanes. From this data, engineers reasoned, they could determine the ideal antenna for each ship.

Ideally, an aircraft transmitter antenna should give out waves in what is called a doughnut pattern. The maximum wave radiation should go out horizontally, with little radiation going straight up into infinity or straight down to the ground. The pattern of radiation is determined largely by the plane's size and shape, since the modern all-metal military ship itself acts as a part of the antenna. Yet it differs from a ground transmitting station because—with the plane flying unattached high in the clouds—it has no ground connection.

By using a miniature transmitting set in a scale model of a fighting plane which, in turn, is mounted on a pole on a huge wooden tower at nearby Patterson Field, the engineers can find the pattern a field of radio waves will take as they emanate from the model. The wave strength is measured by a device known as a field strength meter. Observers stand at the far end of a 70-foot runway atop the 50-foot tower, manipulating the model—which can be revolved on its pole mounting much as a plane would turn in flight—and checking the meter. The model may be placed in various flight attitudes.

The tower test technique was worked out after a number of similar tests made on the ground showed a large margin of error from calculated performance. The engineers found that the only way to simulate transmission of radio signals from a plane in flight was to raise the model off the ground. Result: the tower, built entirely of wood, save for a few bolts of nonferrous metal.

The laboratory confines its research work to projects not of immediate commercial value, although it is in close touch with the radio industry and promptly applies new commercial developments in aircraft radio.

Working in coordination with the aircraft radio laboratory technicians is the second Wright Field organization, the Air Corps instrument-navigation laboratory. This group also works independently on other instrument research.

The combined work of these two laboratories gave birth to the Air Corps automatic landing system, by which two Wright Field officers and a civilian engineer on Aug. 23, 1937, made the first completely automatic landing, without manipulation of the plane's controls by human hands. In other instrument landing systems, the pilot governed his rate of descent and observed his marker beacons at various stages in the glide. The automatic landing device, however, required no effort on the part of the pilot beyond putting the ship into proper position and altitude at a specified distance from the field and closing the master switch which began the landing operation. From there on the entire process was carried out by a series of relays, actuated by impulses from the four radio marker beacons spaced at intervals across the landing area. At a specified interval after the plane passed over the last beacon, the wheels touched the runway and the brakes were automatically applied to the wheels.

Research still continues on automatic landing, with the aim to simplify and further foolproof the system. Only a few years more it is predicted, will see an improved version in common usage. The system may even be reversed to make it possible to take the plane off the ground automatically also, so that the crew's principal duties will be to check the

All Army heavy bombers carry elaborate radio equipment and a competent radio operator, usually an Army-trained enlisted man.

(*Continued on page* 210)

"Mocked up" communications set helps instructor explain microphone technique to these Randolph Field flying cadets. As pilots they must be able to handle planes' two-way radio systems competently.

Majors Carl J. Crane (left) and George V. Holloman pioneered in development of Army automatic radio landings system.

This ship, an obsolete basic trainer, was equipped by Army research men as radio-controlled flying antiaircraft target.

Vitally important to the military airman is the radio homing compass. Its use eliminates necessity of flying airway beams.

PHOTOGRAPHY

Cameras are as important to the Army Air Forces as machine guns. In many ways their shots are deadlier.

by

Lieut. Col.

GEORGE W. GODDARD

George Goddard started out to join the Navy in 1917 and ended up in the Army. Today, at 52, he's one of the world's great photographers, inventor of night air photography, an ace flyer.

EYES that see in the dark, eyes that look through haze and record what is hidden, eyes that reveal natural colors, eyes that see flaws the human eye itself cannot uncover—these are the eyes of the camera which Uncle Sam is using so extensively to help build greater Air Forces.

Photography is being put to startling new uses in our national defense program. To give America the air superiority she seeks to achieve within the next three years, we must determine the best metals, fuels, fabrics and other vital materials for our new fighting planes. The camera is doing its job as it's never been done before.

Specific duties now allotted cameras include searching out weak spots in our aircraft through recording take-off and landing characteristics, photographing instrument dials during crucial stages of test maneuvers and using color film to ascertain details hitherto vague.

Air Force photography today is responsible for training pilots, testing metals, woods, rubber and fabrics and recording plane performances. Aerial photography, now utilizing color films and night flash pictures, is changing the whole military strategy.

The Air Force uses many camera types: special night cameras, high altitude cameras, bomb spotting cameras, high speed cameras, infra-red cameras, long range telephoto cameras, reconnaissance cameras, special color cameras. Each utilizes special films, lenses, filters and other intricate mechanisms Army photographic experts have devised and perfected. Many motion picture cameras of all makes are being used by Army photographers in training and testing procedures.

At present Army Air Force photographic work is divided into three definite branches—training, experimental and tactical.

Air Force photographers are trained at Lowry Field, Denver, Colo., under Lieut. Col. A. W. Stevens, first man to photograph the earth's curvature and one of America's foremost camera experts. Here Army photographers learn in two courses the operation principles of all ground cameras, as well as darkroom technique. Then they are assigned to aerial photographic missions—the advanced course—which trains them in precision aerial camera use. Two primary and two advanced classes are conducted every six weeks, with 75 to 80 students in each class.

But today's real story of Air Force photography concerns the cameras themselves. It centers at the Wright Field photographic experimental laboratory in Dayton, O. Here all new cameras and processing developments have their beginnings. Here devices that have helped make American cameras among the best in the world were invented and put into practical application.

The actual obtaining of aerial photographs is handled by the reconnaissance squadrons in the Air Forces, the reconnaissance and observation squadrons acting in conjunction with, and providing the eyes for, the ground forces; the bombardment units which photograph the accuracy of their own bombing, and a photographic group composed of four squadrons which are located at strategic points in the United States. These last-named squadrons perform the aerial mapping photography functions of the Air Corps and broaden the capabilities of the other tactical units taking aerial photographs.

There probably are about 30,000 cameras now used or on order by our photographic sections. Here are some of the basic types:

For night photography the K-12 camera is used. It has a 13-inch lens, a shutter speed up to 1/100 of a second and a lens speed of *f* 3.5. It takes roll or cut film, size 9x7 inches. The roll film comes in lengths up to 75 feet. The camera on one loading can take as many as 110 exposures. Another night camera is the K-19, still in the experimental stage. Similar to the K-12, the K-19 is operated electrically while the former is run manually. The K-19 has a 13½ inch lens and takes an 8x10 picture. Both cameras are equipped with synchronization devices for the night photographic flash process, to be described later.

High altitude cameras are a little different from those used specifically for night work. Two of the most common now in use are the K-3B and the K-7C, a newer development. Both are electrically operated. The K-3B has 24-inch lenses with three focal lengths. The K-7C takes a 9x18 inch picture. This latter camera also is used for reconnaissance work, making oblique photographic maps and prints. Also used for the oblique photographic mission are the K-10 camera, now almost obsolete, and the newer K-20, which will be sent to all photographic squadrons some time in December. The K-10 took 5x7 pictures; it was operated by hand, held oblique to the airplane. The K-20, an improved version of the K-10, also is held by hand and operated manually, but it takes a 4x5 picture on roll film, with space for 50 exposures.

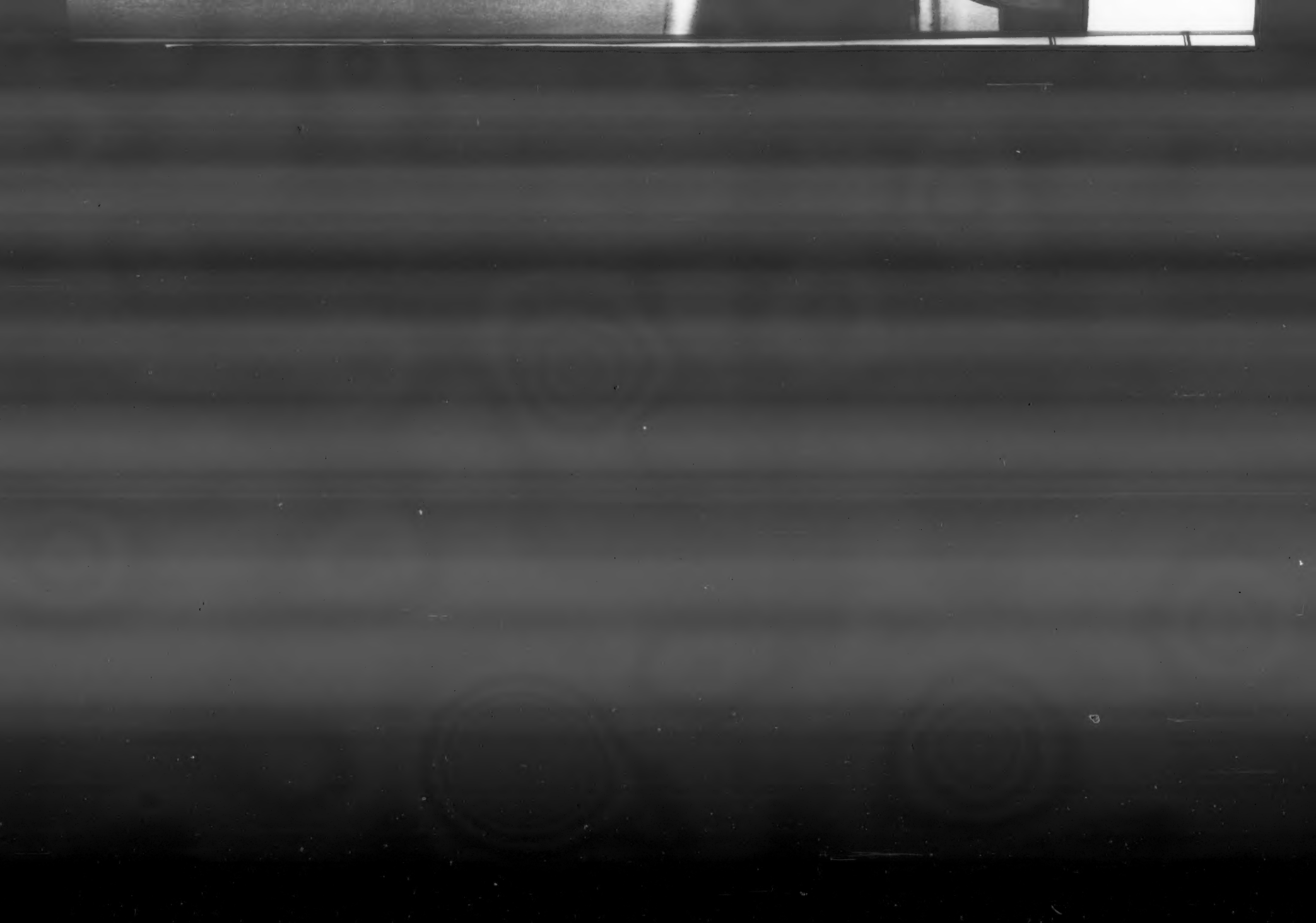
Two types of aerial cameras are used for long-range photography. All are equipped with telephoto lenses. Designated

(*Continued on page* 107)

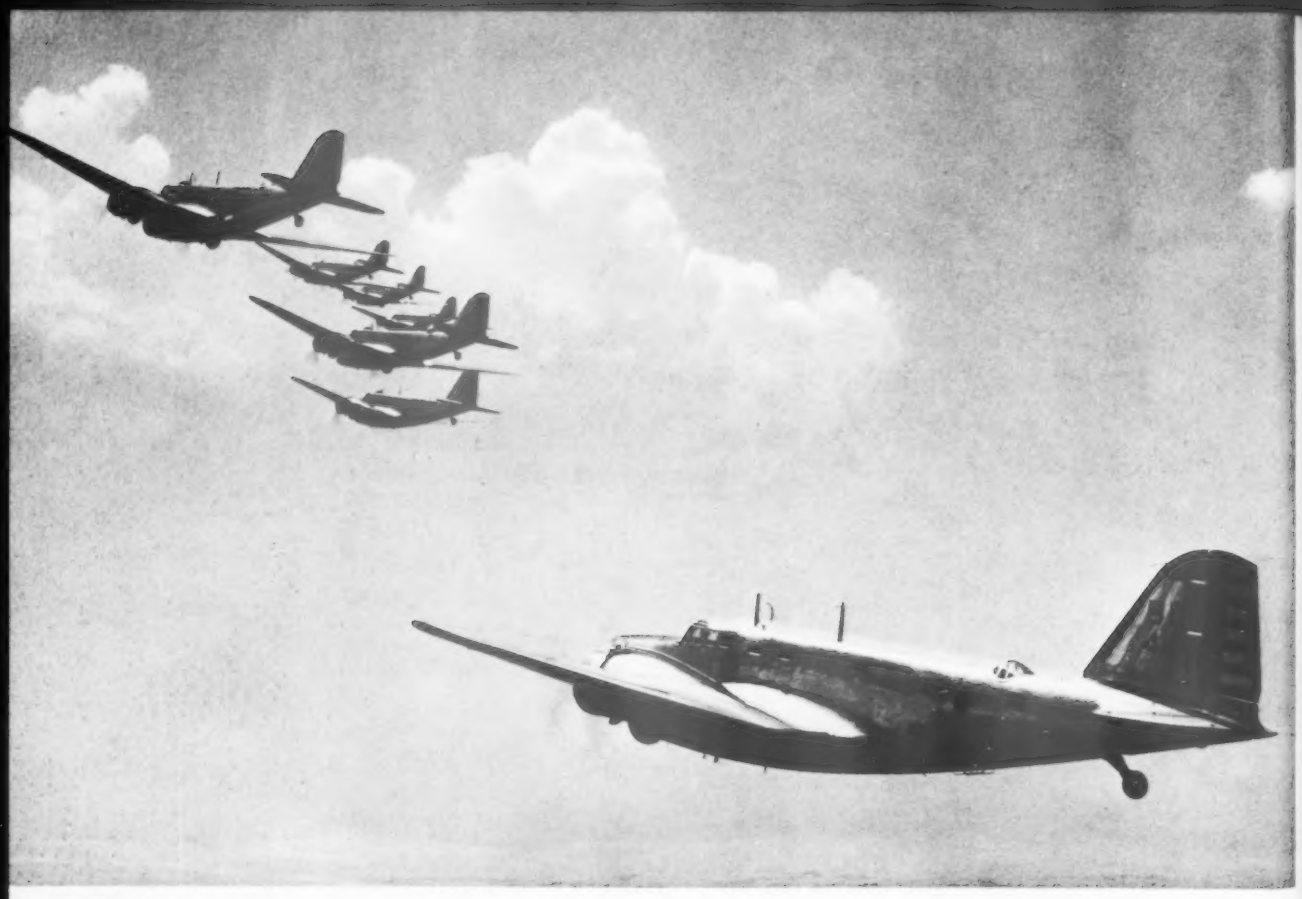
AVIATION SALON

On the following eight pages are glimpses of the Army Air Forces as seen through the lenses of four of the country's best aviation photographers.

Aircraft shown in this salon include the Douglas B-18A, Curtiss P-36A, North American BT-14, Beechcraft F-2 and Douglas B-19.

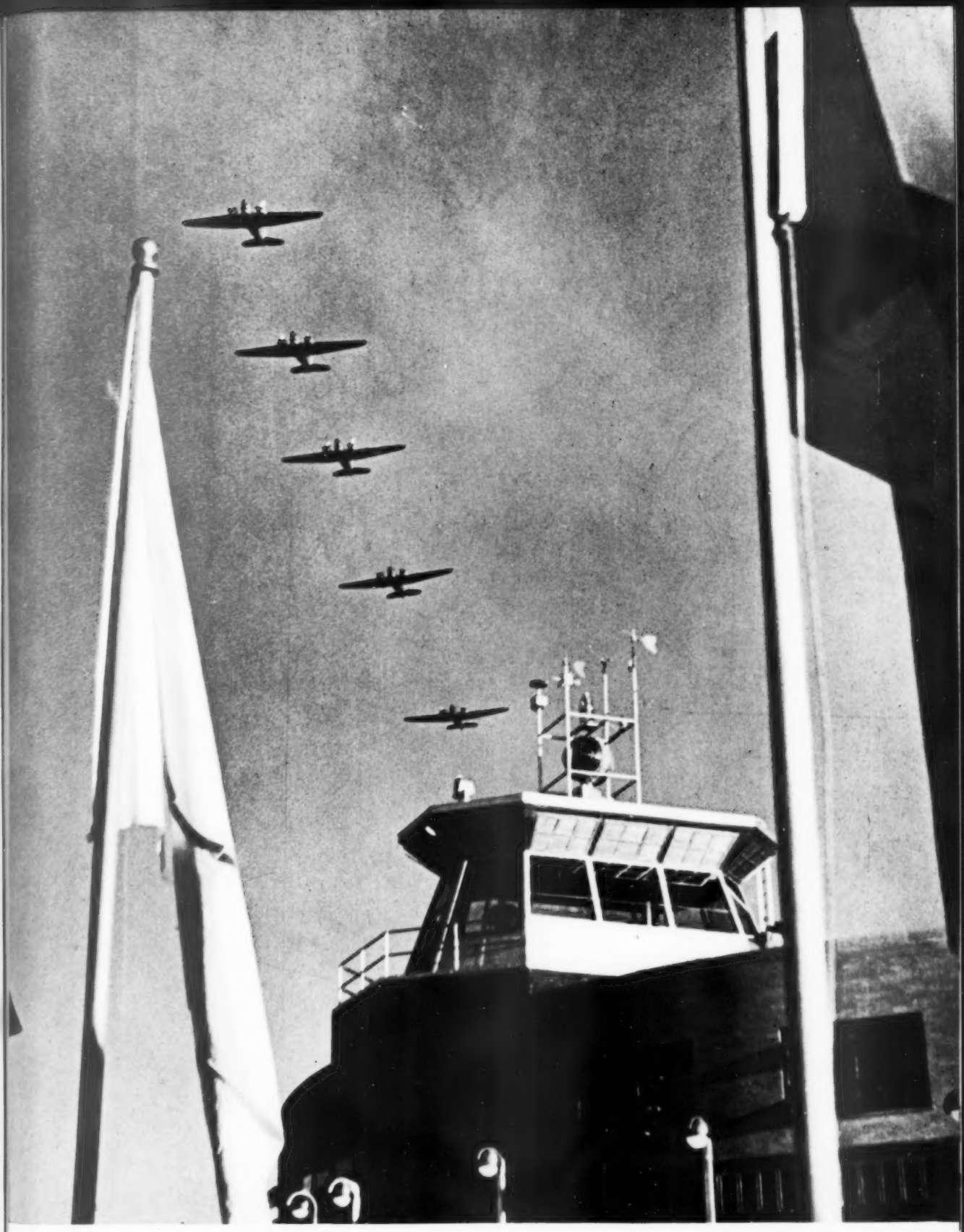


TROUBLE SHOOTER By HANS GROENHOFF

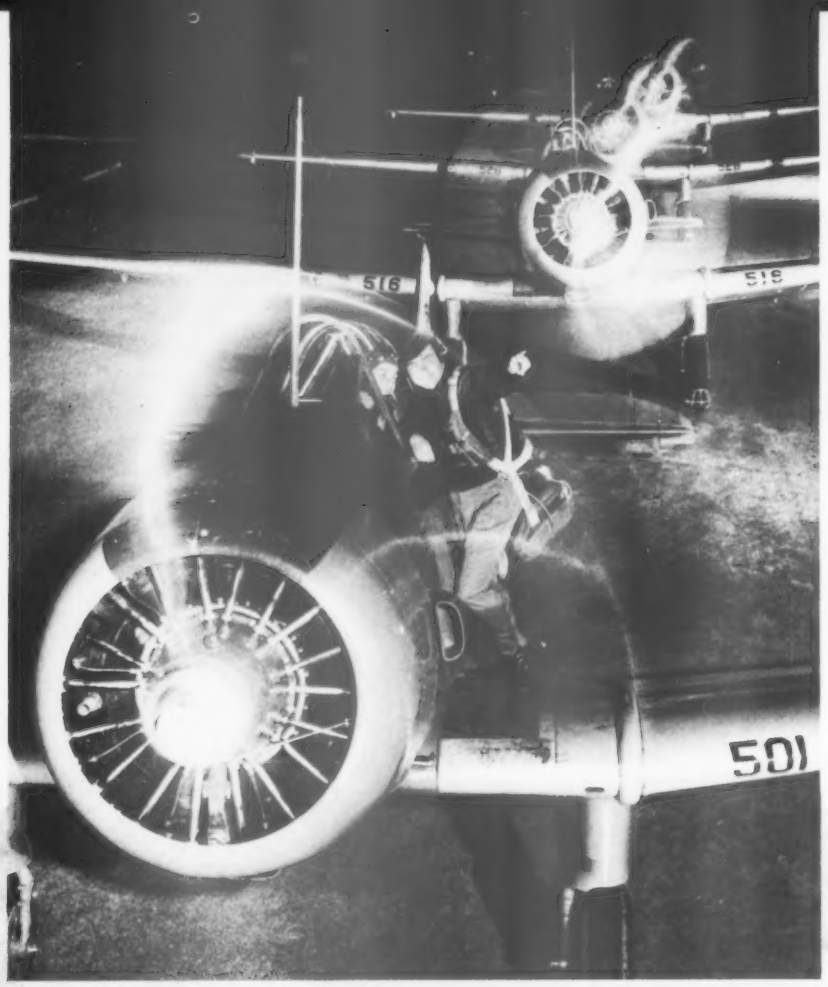


UNDER ORDERS By Hans Groenhoff

IN TRAINING By Sgt. Leslie W. Bland



COMING HOME By HANS GROENHOFF

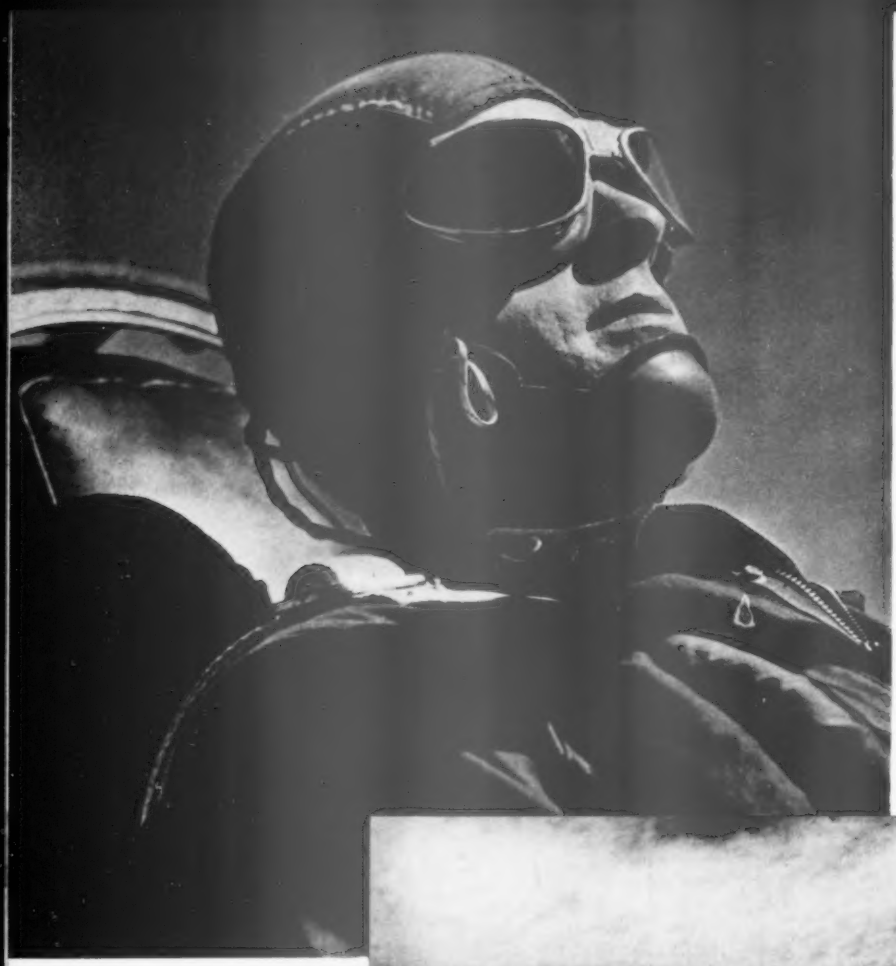


NIGHT HAWKS

By Sgt. Leslie W. Bland

RANDOLPH FIELD

GARGANTUA By LAWRENCE W. KRONQUIST



FIGHTER

By Hans Groenhoff

MISSION COMPLETED

FI

FLYING CAMERA

By HANS GROENHOFF

AT EASE By HANS GROENHOFF

PHOTOGRAPHY

(Continued from page 98)

the K-16 and K-15 types. Both take 5x7 pictures on roll film or cut film.

Most important to ground maneuvers are precision mapping cameras. Standard equipment in the Air Forces is the T-5 model, which has a wide-angle lens and takes a 9x9 picture on roll film. Another type is the T-3A. These cameras are high-precision photogrammetic types. They are designed with special built-in view finders, shutter mechanisms, etc., which have been developed by the Wright Field photographic experimental laboratory experts.

On many missions the Army now is using two T-3A cameras mounted in tandem on the same mount frame at 45° angles to each other, thus making an octagonal picture whose distance from side to side is one mile from each 1,000 feet of altitude. If an airplane using this tandem mounting were flying at 25,000 feet it would take in an area of approximately 550 square miles. The T-3A, mounted in tandem, takes one vertical photograph and eight oblique photographs. The Army is experimenting with a new T-5 single lens mapping camera equipped to record on one film the time of day, date, serial number of the negative, altitude, speed, verticality of camera and all data pertaining to the photographic mission which might be of help in working out tactical maneuvers or test problems.

The Wright Field motion picture unit uses mostly 16 mm. motion picture cameras, hand held, with 1-, 2- and 4-inch lenses. These cameras are spring wound and are on turret head mounts. They will take only 100 feet of film in one loading. The Air Forces, however, are using 35 mm. motor-driven tripod cameras with magazines holding 200 feet. These are equipped so new magazines can be loaded while the airplane is in flight. The 35 mm. movie camera has 2-, 4- and 6-inch lenses.

The Air Corps photographic research laboratory has devised many new methods for taking and processing pictures. One outstanding technique permits photographing, developing and printing a picture in the airplane so speedily that the finished print may be dropped from the plane within four to five minutes after the exposure has been made. But even this speed is not fully satisfactory; we still are seeking further shortcuts to reduce the time. Using prompt, accurate information on enemy troop movements, as well as the quick photography method, Air Force cameramen can supply definite photographic records of the effectiveness of long-range artillery within a few minutes after a salvo has been fired. They also can locate targets far out of sight, but within range of the big guns, by spotting them in photographs in relation to already known landmarks.

Most important factors in the quick photography method are a compact, four-compartment processing tank which may be installed in any Air Force tactical ship larger than a single-seat pursuit plane; a special type of cut film holder which is used continuously as a camera holder and a processing holder; and a small but highly efficient printer operated in a light-proof zipper bag.

The Air Force has tried the direct positive method of photography, whereby the picture is taken on photographic paper which, when developed, itself becomes the finished print. But this method has been discarded in favor of the conventional system of exposing a negative, then transferring the image to a positive print. The experts found the direct positive method could be used only under favorable daylight lighting conditions; even then the exposure had to be just right.

Taking off and flying high over the airport selected as their pictorial objective, the pilot swings the plane and the cameraman "fires" his telephoto-lensed camera, designed for making oblique photographs. He doesn't have to focus. He is far enough from the ground so the camera has a fixed focus at infinity—except when using infra-red film—where a special infinity focus is required. All he has to worry about is exposure and lens opening.

As soon as the exposure is made, he takes the holder from the camera and immerses it in the tank's first section. He pulls the slide up out of the holder so that it sticks up above the tank and uses it as a handle to agitate the holder in the

BLITZ DARKROOM IS ARMY'S LATEST

Reconnaissance plane above drops exposed films (arrow) to waiting photo plane which has new "blitz darkroom" set up and ready.

Soldier rushes exposed films to darkroom. Special tent is set up by inflating its pneumatic ribs from a compressed air tank.

Photographer above develops and prints negatives in five minutes with portable equipment. "Blitz buggy" below then rushes prints to field commander, while photo plane takes off on new assignment. Entire system was invented and perfected by author.

This night flash-bomb picture illustrates military value of this type of photography. Clearly shown on the above Louisiana base are planes, highways and soldiers' tents.

Lieutenant Colonel Goddard is shown in the door of a bomber with photo flash bombs.

tank so that the negative is fully treated in the developer for one minute. Replacing the slide, he removes the holder and transfers it to the second section of the tank, where it gets the same agitating process for 15 seconds, in a "stop bath" solution. The negative then gets 75 seconds in the third tank, a "fixing" solution, and a five-second water rinse in the fourth tank.

Each section has a non-spill lid, so that the plane can do ordinary maneuvers without spilling chemicals. The tank is jacketed in an insulation material one and one-half inches thick, electrically heated to a 75° constant temperature.

After its rinse, the negative is quickly sponged off with a rubber squeegee, similar to those used by window washers, to remove extra moisture. It then is placed on the printer contact surface and covered with a sheet of transparent material, to keep the printing paper from getting wet. The sensitized paper is placed over the negative and the lid is brought down to make the exposure. The printer gets its exposure light from a single bulb, near the source of contact but shielded so it throws its light down to a reflector and is in evenly diffused parallel rays, with no chance of unequal light distribution.

To the trained photographer there is nothing unusual about this procedure, but it must be remembered that the quick-work photographer has his arms thrust into that black zipper bag and is doing everything without seeing what he does.

As soon as the print is made, the paper is placed in a holder similar to that used for the film, speeded through the same four processes of developing, stopping, fixing and rinsing. It takes two minutes and 35 seconds to process the film, 30 seconds to squeegee it and from five to 10 seconds for printing. Now it takes 20 seconds to develop the print, 20 seconds for stop bath, 15 seconds for fixing and five seconds for rinse. Print drying is eliminated by use of wax-treated paper which sheds surplus moisture. The print is placed in a light metal tube container with sponge rubber shock absorbers and dropped over the side to the ground. Time totals four minutes and 15 seconds. Wright Field officials have checked the complete process in under five minutes, including time required for transferring negative and print through the various processing stages.

Quick photography, Air Forces style, has been a research subject ever since the days of Dayton's old McCook Field laboratories in the early 1920's. The first quick photograph of unusual significance was a picture for President Coolidge, made at Dayton, from an airplane. The plane followed the presidential train to nearby Xenia, where the finished print was dropped to the station and handed to the president.

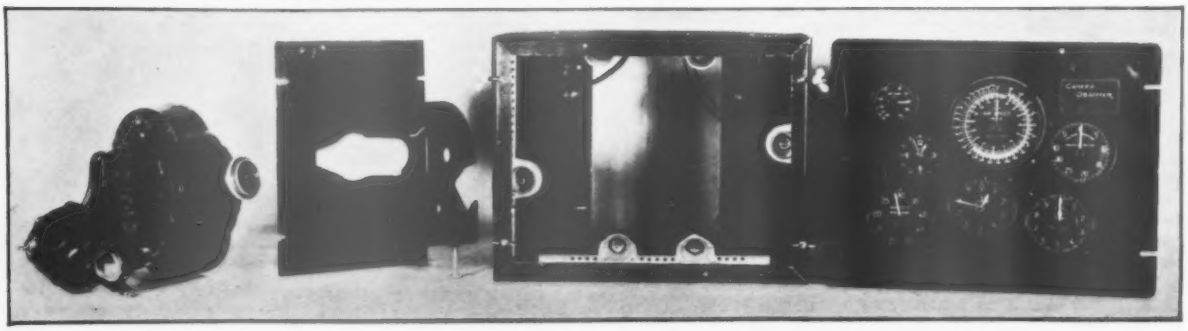
While the idea is not new, present day speed indicates improved methods. A new type photographic paper holder is being produced experimentally to eliminate need for the hood over the printer. It will have the sensitized paper pasted in place, so it can be laid on the contact surface, the top brought down and the slide pulled from the holder, making the exposure. As soon as the paper is processed holder and all can be dropped to the ground, with a streamer attached, thus making unnecessary use of the tube container. The new holder will be of plastic or some other material discardable without great loss after a single use.

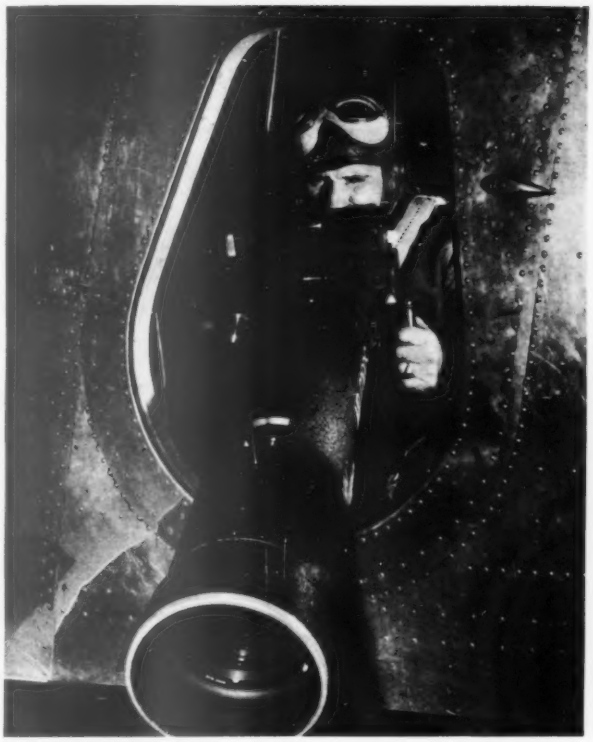
The laboratory men are continuing to work, too, on papers, films and chemicals, to obtain still higher speeds. Eventually it is possible the direct positive method again will be used, assuming that the limited emulsions, now the best obtainable, can be superseded by new ones which will give a wider light range.

New aerial photographic equipment developed at Wright

(*Continued on page* 150)

Complete, permanent records of test flights now are made by automatic motion picture cameras which photograph complete instrument panels (right). Test pilots formerly recorded data on scratch pads.



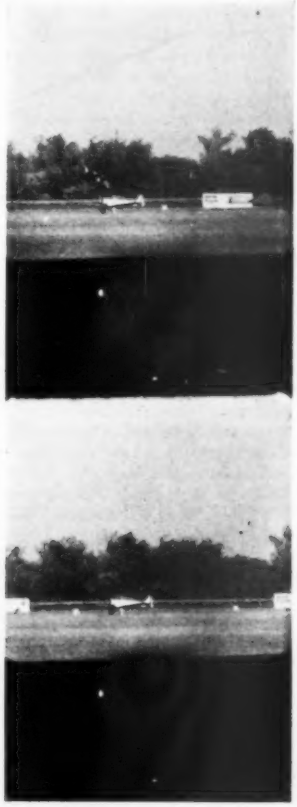


This Fairchild "Big Bertha" is used by reconnaissance planes for high altitude oblique photography. Door is that of Beechcraft F-2.

Photographic giants like this vertical mapping camera cost many thousands of dollars. Photo maps are made by overlapping shots.

← All Army photo sections come under the command of Wright Field. They are responsible for tactical photographic activities and all processing.

Mosaic maps of whole areas are made by assembling trimmed and corrected prints to scale on table. Each photograph includes a 40 per cent overlap to guard against possibility of missing subject.



Automatic movie camera records plane landing and take-off for performance figure calculations.

METEOROLOGY

Army Weather Service men rank among the world's best forecasters. Their skill is a vital factor in air safety.

by Lieut.
RICHARD ARNOLD, Jr.

Born Dec. 22, 1913, in Brooklyn, N. Y., Lieutenant Arnold joined the Air Forces as flying cadet in 1937. He is graduate of Connecticut University and M.I.T. He is weather officer at Patterson Field.

MILITARY airplanes must fly in all kinds of weather. But in order to keep them flying it is important to their pilots that they be informed at all times of weather conditions that lie ahead so that they can fly with comparative safety. For this reason the Army has established one of the most efficiently-operated weather services in existence.

Known as the Weather Service, U. S. Army Air Corps, the organization is designed to increase the percentage of military missions successfully performed and to reduce to a minimum accidents due to weather hazards. When Air Forces tactical units go into war or on maneuvers, weather units go along with them, maintaining constant contact with the vast forecasting service behind the lines.

Air Corps Weather Service is a separate unit, functioning under the direction of Maj. A. F. Merewether in Washington, D. C., and directly responsible to the Chief of the Air Corps. It operates with the aid of a complicated network of weather stations spotted in hundreds of localities in every section of the United States and its possessions.

Continental U. S. is divided into four weather regions: Northwest Region, with headquarters at McClellan Field in Sacramento, Cal.; Northeast Region, with headquarters at Patterson Field, Fairfield, O.; Central and Southwest Region; Duncan Field, San Antonio, Tex.; and the Southeast Region, at Maxwell Field, Montgomery, Ala.

The Northwest Region reports weather conditions in California, Idaho, Montana, Nevada, Oregon, Utah, Washington and Wyoming;—the Northeast Region covers Connecticut, Delaware, District of Columbia, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin;—the Southwest Region covers Arizona, Arkansas, Colorado, Iowa, Kansas, Minnesota, Missouri, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota and Texas;—the Southeast Region covers Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina and Tennessee.

Weather squadrons are assigned to each regional area. Five weather squadrons operate abroad in the Philippines, Newfoundland, Hawaii, Alaska and Panama. Each weather squadron consists of a headquarters section and the enlisted personnel assigned to the various weather stations which are located within the squadron's control area. Personnel numbers between 320 to 380 men to each squadron.

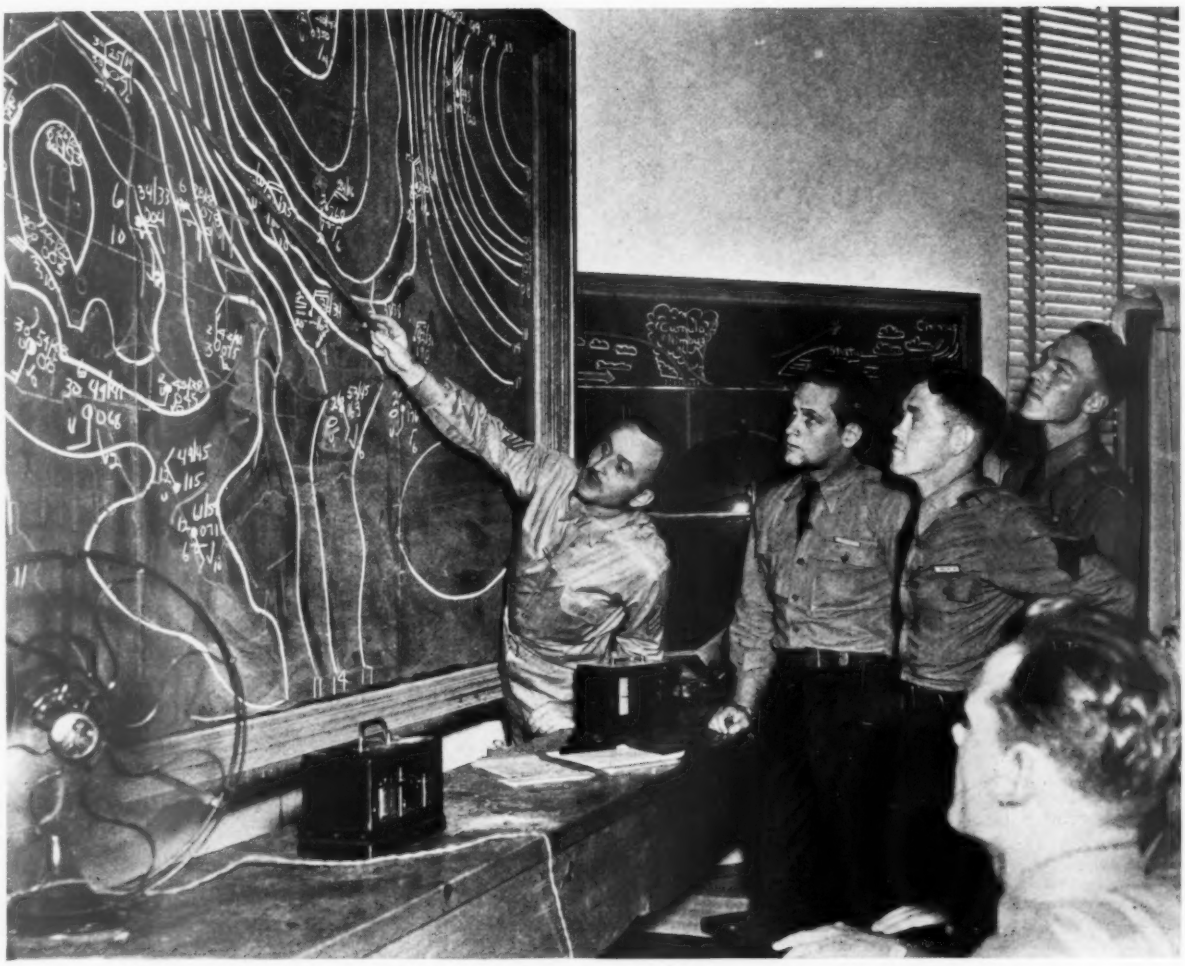
Weather Service itself, consisting of observation and forecasts, and the preparation of weather maps and charts, is performed by fixed weather stations, by temporary field weather stations and by mobile stations assigned to Air Corps tactical units.

There are various types of weather stations. The base station is comprised of 15 men and two officers. The officers must be qualified meteorologists and the enlisted men must be qualified as forecasters or observers. Base Stations are located at Langley Field, Selfridge Field and other fields where tactical units are stationed. Post Stations, the next unit in the organization of weather squadrons, consist of 10 men, one officer qualified as a meteorologist and three forecasters. They are located at various sub-depots and training centers. Squadron stations, which have one weather officer and eight trained enlisted men, are located at such points as Ft. Knox, Ky.; Ft. Sill, Okla.; and at other Army posts. There are also Detachment Weather Stations and Airways Observer Stations at airports and cities where there is less military aviation activity. All of these supply information on weather conditions to the flying activities by means of teletype systems linking all points.

Theodolite enables weather observers to check wind conditions at various altitudes, as shown by pilot balloon.

Every airplane that leaves the ground is served by a corps of experts scattered from one end of the U. S. to the other who are on the alert 24 hours a day and ready to warn the pilot through their radio and teletype network of the slighest change in weather conditions that might prove dangerous to his flight. These experts are on duty at the various stations and bases.

To meet the expansion requirements, the Air Corps began last July to train 150 meteorologists at universities throughout the country. Those who complete the training are commissioned second lieutenants in the Air Corps reserve and will be assigned to the various stations. The Air Corps is also training enlisted men at Chanute Field, Rantoul, Ill., to be weather forecasters and



Meaning of isobars, isotherms, Beaufort wind scale, etc., are pointed out on weather map by flying cadets' instructor. As pilots, they will receive up-to-the-minute reports on changing conditions aloft from the Weather Service.

weather observers. They will have specialists' ratings.

This training includes a three months' weather observer course that is given four times a year and a six months' weather forecaster course given twice each year. To be eligible for either course, a man must be serving a three-year enlistment in the U. S. Army. He must have a high school education and should show a special aptitude for this training as indicated by grades made in the Army classification tests and mathematics examinations. Candidates for the forecaster's course must have completed an observer's course satisfactorily and are required to pass an entrance examination in elementary mathematics and physics. Students who complete these courses are then ordered to weather duty at the various stations.

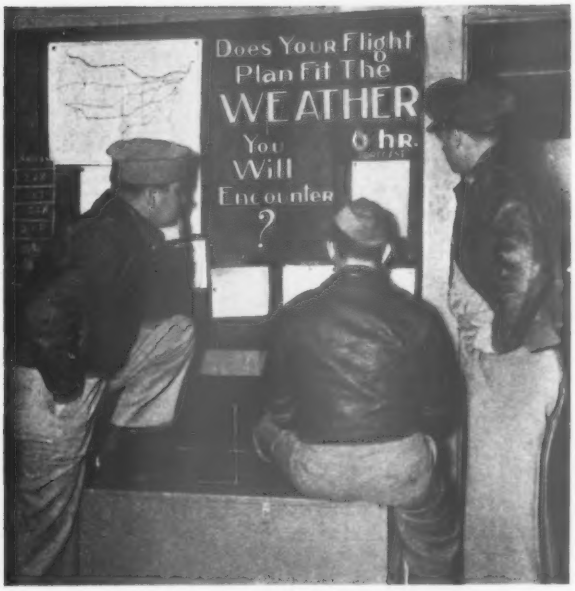
The enlisted man who chooses the weather service must know mathematics, including algebra through quadratics, logarithms and plane trigonometry. He must train himself to know a new vocabulary which includes such words as thermodynamic, tephigrams, isalobars, millibar, isobar and adiabatic. All of these are essential to the observer and forecaster in making up his reports at the various weather stations.

This course is designed to qualify students as weather observers capable of performing all routine duties required at all types of weather stations, except weather forecasting and radio receiving. Principal emphasis is placed upon practical instruction in conducting surface weather observations, wind aloft soundings, maintenance and repair of weather instruments, weather records and the plotting of data on weather maps and all auxiliary charts. A course in elementary meteorology is also included.

The weather observer's course covers a period of 12 weeks; 60 hours are spent on meteorology, a course in elementary meteorology covering the study of the atmosphere, weather elements and their interrelation, atmospheric circulation and climate; 22 hours are spent on surface observations—practical exercises in taking weather observations from the ground; 15 hours in upper air observations—practical exercises in making pilot balloon observations of wind direction and wind speed at various levels; 120 hours in plotting map signals, decoding weather reports and entering data on weather maps; 15 hours in plotting wind aloft reports; 45 hours in checking and plotting atmosphere radio reports; seven hours in plotting insentropic charts, basic data for insentropic charts and actual drawing of the charts; seven hours plotting atmospheric cross sections; 60 hours on weather instruments in laboratory exercises in care and repair of these instruments; 22 hours in practical exercises in the preparation of all weather forms; and 22 hours as teletype operators preparing teletype perforated tapes and the transmission of messages over local circuits.

The weather forecaster's course places its principal emphasis upon instruction in physical and dynamic meteorology and in practical exercises in air mass analysis, frontal analysis and practice forecasting. Instruction is also provided in mathematics and physics sufficient to enable the student to understand the more advanced subjects of modern weather theory. There is also a short course in weather station organization and management.

A typical base weather station is operated by two officers, both of whom are graduates of a weather course at a technical university, and 15 enlisted men, among whom are four forecasters, three radio operators, and weather observers, one



Hundreds of stations supply 24-hour-a-day data for these forecasts. Note effort to make pilots weather conscious.

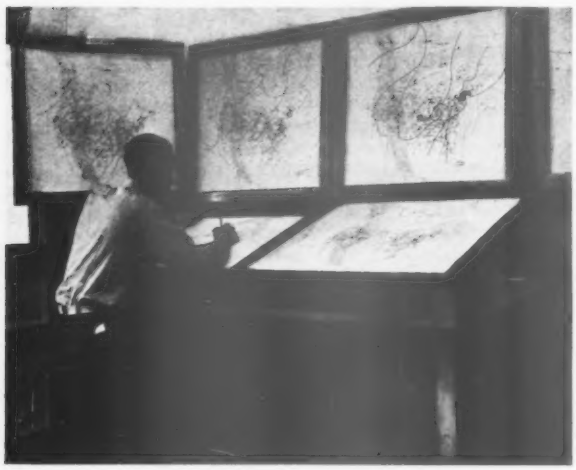
repair man for equipment, one clerk to handle records and six teletype operators who are also weather observers.

These men compile, during 24 hours a day service, records and reports that include the following facts in message form to all other weather stations connected by teletype: location of the station, time, ceiling, state of sky, height and character of clouds, visibility, weather, obstructions to visibility, temperature, dew point, surface wind direction and speed, atmospheric pressure, pressure change in last three hours, amount, kind and direction of clouds, state of landing field, upper air velocities at even 1,000 foot levels and the highest elevation observed.

Each regional control office conducts continuous studies of seasonal climatic conditions within its control area. It maintains throughout this area a 24-hour weather reporting service. It makes upper air observations of wind velocity by pilot balloons twice daily at an altitude of at least 15,000 feet, and one night balloon observation each month. In addition, each station maintains 24-hour weather teletype schedules for the reception of additional weather information from the U. S. Department of Commerce weather Bureaus.

Whenever the ceiling is less than 1,000 feet and the visibility less than three miles, or whenever other hazardous weather conditions exist or are anticipated within an hour, information for radio broadcasts of local weather conditions are made available to the airdrome control station every 15 minutes or whenever requested.

Checking and plotting insentrophic charts, atmosphere radio reports and other data sheets are part of Service training.



Forecasts are issued by base weather stations as needed and contain information showing the state of weather to be expected, precipitation, ceiling, visibility, surface wind, upper air winds and hazards.

At each of the major weather stations, and at some substations, a variety of weather recording instruments are employed. Kept inside a special outdoor cabinet are maximum and minimum thermometers. The maximum thermometer records the highest temperature for the day. It is filled with mercury and is mounted at an angle so that the liquid will not go below the highest temperature recorded during the past 24 hour period. The minimum thermometer is also mounted on an angle and is filled with alcohol so that the lowest temperature is recorded and maintained for record at the daily check up.

Also inside the "instrument shelter" is a hydrograph which records the changes in humidity. Human hair is used in this instrument because this substance is said to be the most sensitive to moisture.

Most common of the instruments used at the base stations are the barometer and anemometer, which indicate atmospheric pressures and wind directions and velocities. The barometer is a glass tube filled with mercury and scaled to the thousandths of an inch. The weight of the air acts upon the mercury causing it to rise and fall as pressure increases or decreases. This information is helpful to the pilot, who can determine by applying the data obtained to his own instruments in the airplane, just how high he is above the ground as in the case of dangerous visibility hazards such as fog. The anemometer and vane indicates the wind velocity and direction thru the use of an arrow pointing into the wind just as your weather vane does. The cups, mounted on a spindle, are spun around as they catch the wind making possible velocity readings.

In addition to this information obtained from instrument readings, the forecaster receives information pertaining to weather conditions at every weather station hourly. This is transmitted in code over teletype machines. Various standard symbols simplify the teletype messages. The symbols have various meanings such as: C for contact weather; N for instrument weather; X means closed to all aircraft. There are approximately 35 stations on each teletype circuit and there are several circuits within each regional control area.

At certain stations radiosonde observations of the upper atmosphere are made. This operation is accomplished through the use of delicate radio equipment. A small radio sending set, weighing only a pound and a half, and containing simplified instruments, is attached to a 6 ft. balloon filled with helium or hydrogen. The balloon is allowed to rise of its own accord carrying the radio equipment which immediately begins to broadcast to a receiver in the station, the conditions of the atmosphere found through effects on the inclosed instruments. Changing pressures, temperatures and varying amounts of water vapor in the air are thus recorded. The balloon gradually grows larger due to the lessening of the weight of the air upon it until it has reached an altitude of about 70,000 feet where it has reached a size of nearly 25 ft. in diameter whereupon it bursts and the radio falls slowly to earth by parachute.

The instruments attached to the parachute released from the radiosonde balloon are marked for return to the respective weather stations. Uncle Sam pays $5.00 each for the return of the small radio units.

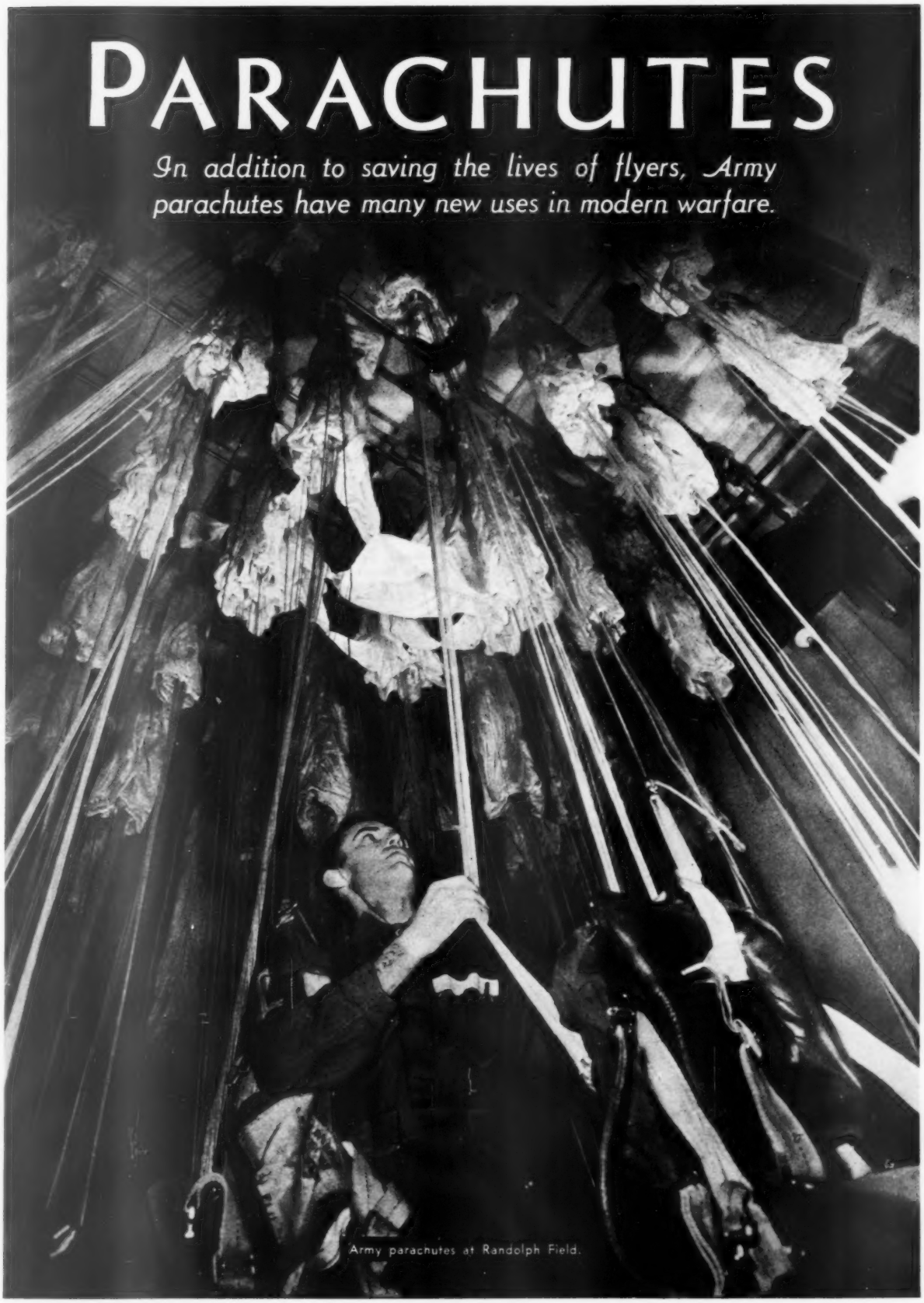
Records of barograph, balloon reports, thermometers, barometers, theodolites and other delicate instruments help meteorologists and enlisted men compile charts for pilots. These include upper air diagrams, pseudo-adiabatic diagrams, tephigrams, insentropic charts, surface synoptic maps, vertical cross sections and other charts.

With these, the forecaster gets an instantaneous picture of the weather over the entire country and from this data he can make predictions and accurate weather reports that enable pilots to follow the weather conditions over their route.

END

PARACHUTES

In addition to saving the lives of flyers, Army parachutes have many new uses in modern warfare.



Army parachutes at Randolph Field.

PARACHUTES

By
FRANK G. MANSON

A civilian engineer and chief of the Wright Field parachute unit, Mr. Manson has been with Materiel Division for 20 years. He is accredited with designing new type belts, shoes and clothing for Army's airmen.

Twice each year every Army parachute must be drop-tested from an airplane. These two sergeants are preparing dummies for test.

WHEN World War I was drawing to a close, observers on the ground were surprised to see men leap from burning planes and float easily to earth beneath the canopies of giant silken umbrellas. Already a regulation part of the balloon observer's equipment, the parachute was then, for the first time, being used by airplane pilots. The Germans widely used a device attached to the airplane itself; it often failed, but saved a few lives. The Allies experimented with the 'chute, but before anything really successful could be designed the war came to a close.

The first escape by parachute from aircraft in emergency probably was accomblished by Jordaki Kuparento in July, 1904, when he leaped from a burning balloon in a crudely-fashioned "life belt" umbrella.

In March, 1912, the first parachute jump from an airplane was accomplished successfully. This was a test jump using the fixed-type parachute. The jump was made by Bert Berry near St. Louis, Mo., over Jefferson Barracks. The airplane was a Benoist biplane with an open cockpit. Anthony Jannus was at the controls. The flight reached a comparatively high altitude and the men were numbed by the cold. The parachute was carried in a metal cone attached to the plane. When Berry—whose body was tied to the 'chute with a long rope and other harness—jumped, the jerk of his falling body pulled the 'chute from its container. He fell about 300 feet before the 'chute blossomed and floated him easily to earth.

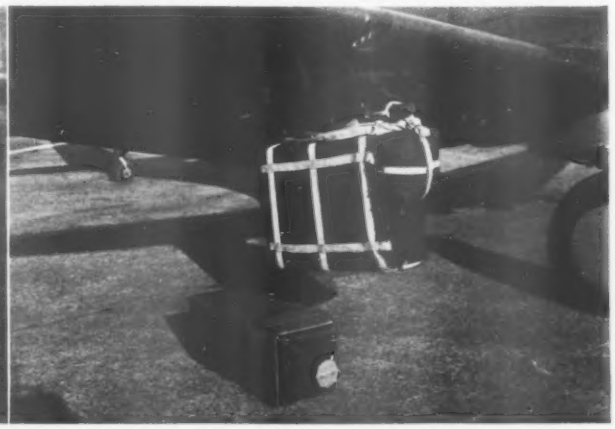
During the World War the parachute saved approximately 140 Allied balloonists' lives. With leaps being made from altitudes between 250 to 5,000 feet, there were but five casualties recorded during the whole period.

After the Armistice the Air Corps at McCook Field, led by Maj. E. L. Hoffman, began extensive research into the principles of the parachute. Manufacturers everywhere were encouraged to send in parachutes or ideas. Even some foreign designers submitted their developments.

There were many attempts and many failures. One July afternoon in 1919, a young English officer of the Royal Flying Corps (today's RAF) made a demonstration jump. His 'chute harness broke at an altitude of 600 feet and he plunged to his death. From this tragedy engineers learned many facts which

Parachute troops are not part of the Army Air Forces, but merely ground soldiers carried on their mission by Army transports.

Special parachutes have been developed by the Army for dropping food, supplies and equipment to ground troops in distress.



At Randolph Field alone there are 1,000 parachutes in daily use. Since the big training base opened 10 years ago, 31 instructors and cadets have saved their lives in leaps from disabled training planes.

later helped solve vital problems in parachute development.

Up until that time every parachute was attached to the airplane. Either the 'chute was carried on the pilot's back in a small pack fastened to the plane with a long rope, or the parachute was carried on the airplane in a container beneath the fuselage or wing, a rope attaching it to the pilot's harness. Both ideas worked satisfactorily, since the falling body's weight jerked open the parachute. On the plane from which the Englishman jumped, the parachute was attached to the fuselage in a drum-like container. When he jumped the rope became tangled in the fuselage and snapped.

From study of this accident, McCook Field engineers saw that there was only one place for the parachute: on the aviator. This has been standard practice ever since.

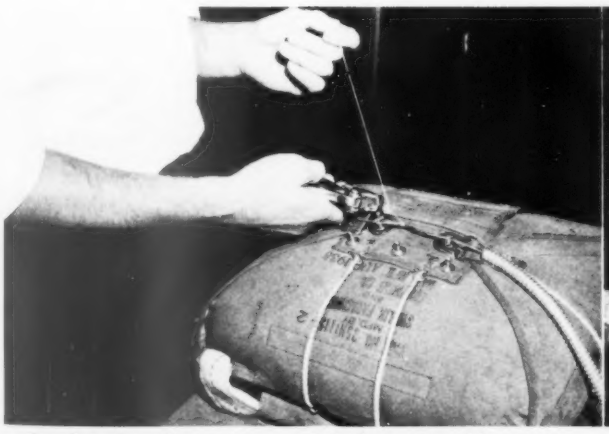
First, engineers had to answer this question: How would such a parachute open? It was apparent that if the jumper himself were free of the airplane before his 'chute was opened he would have to open it himself. Few people believed that a man falling through space at a terrific rate of speed could keep his senses long enough to pull any mechanism.

Again, the English flyer's death answered a vital question. Observers who saw his body twisting and turning in the air said he was trying desperately to get the 'chute harness adjusted to save himself.

Several officers at Mitchel Field, N. Y., volunteered to leap from an airplane and fall several hundred feet before opening their parachutes to see if there was any proof to the theory that man lost his senses during a fall. Each kept his senses perfectly. Later, after the development of the free 'chute was a success and the parachute became standard equipment in the Army, Col. Albert W. Stevens, now commanding officer at Lowry Field, Denver, Colo., fell nearly 11,000 feet in 1924 before opening his 'chute!

There is only one "person" who could tell the whole story about the parachute's progress during those early days, but he can't talk. He's "Dummy Joe, hero of 5,000 jumps". It was his senseless form that actually did the hard work of going overside in testing the various types of 'chutes studied at McCook and Wright Fields.

(*Continued on page* 168)



Parachute rigger here sews up packed 'chute. Two rubber shock cords jerk open pack when rip cord (tube at right) is pulled.

One of the most foolproof of mechanical devices, the parachute is packed by trained riggers. Nylon soon may replace silk.

POWER PLANTS

Engines, propellers and leak-proof fuel tanks get their start in this quiet, inconspicuous branch at Wright Field.

by Lieut. Col.
EDWIN R. PAGE

Chief of Wright Field's Power Plant Branch, Lieutenant Colonel Page joined Signal Corps Aviation Section in 1918. A non-flying officer, he is 57 and one of Air Corps' best engine authorities.

TOGETHER, engines and propellers make a team. Nowhere in flying is smooth, precision-engineered teamwork shown to better advantage than in their mutual helpfulness. The study of that teamwork is one of Wright Field's most important jobs. It has progressed steadily ever since the first airplane flight. Today, at Wright Field, 2,000 h.p. engines are undergoing tests; new equipment, now being constructed, will reveal secrets of power plants four times that big. When designers produce the engines, the Air Forces will be ready to test them and to fit them with proper propellers.

The biggest engine-propeller team in current use is the 2,000 h.p. Wright *Duplex Cyclone* and its 17-foot electric propeller, developed for the Douglas B-19. Tomorrow's engines will take propellers 24 feet in diameter, some with as many as 10 blades, others with two sets of blades rotating in opposite directions.

The only limiting factor on the designer's horizon is available engines' output. He cannot design a plane no existing engine can lift. But he can, on paper, design a super-ship and wait until Wright Field testing laboratories finally approve an engine which science knows will drive the plane at the required speed.

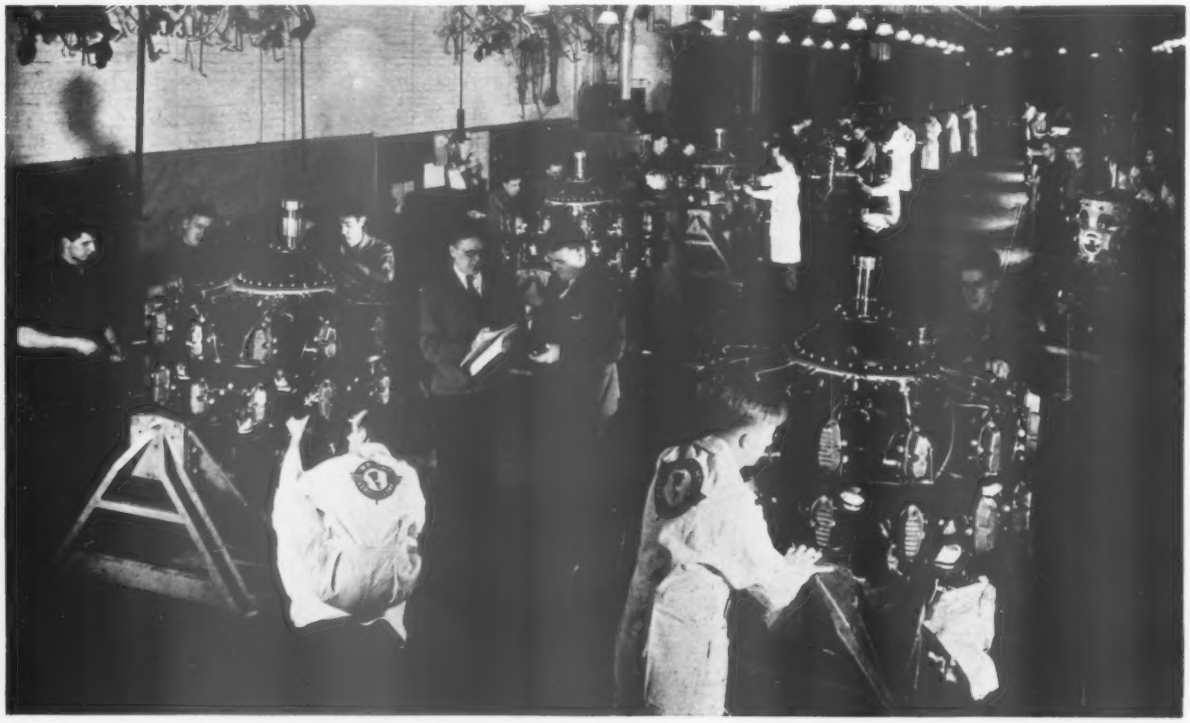
The engine has to come first in any design. Aviation history shows virtually every successful "first flight" was a triumph for a new type of engine. The Wright brothers originally conquered the air because they had an engine that would lift their plane. In 1909, their first military plane, carrying a pilot and passenger, flew an hour and 23 minutes with a 25 h.p. motor. The same year Bleriot flew his monoplane across the English channel with a 28 h.p. engine. These pioneers designed their own engines.

The World War speeded competitive engine design by commercial factories. By 1916 Rolls-Royce had a 250 h.p. V-12 engine in production. In 1917 came the first practical 1,000 h.p. design, built by Fiat for Italy's huge Caproni triplanes. Here in America the Liberty engine was designed and built so fast, under unusual wartime pressure, that at the close of the war five American manufacturers had built 13,396 of them.

Today's high-powered radials were made possible when S. D. Heron of Wright Field's power plant laboratory produced a valve which assured internal cooling of high-power cylinders.

(*Continued on page* 158)

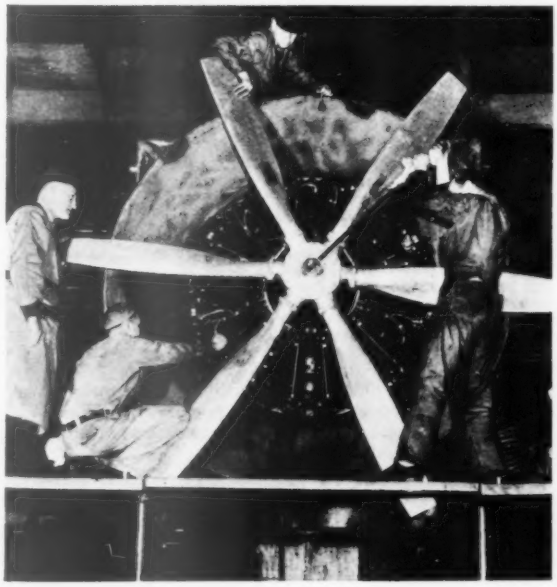
Not until Wright Field's power plant branch okays an engine can a manufacturer put it into production. These 1,700 h.p. twin-row Wright "Cyclones" now are in production for Army bombers and transports.



Developed originally at Wright Field, leak-proof tanks are going into all Army combat planes like this Douglas A-20A.

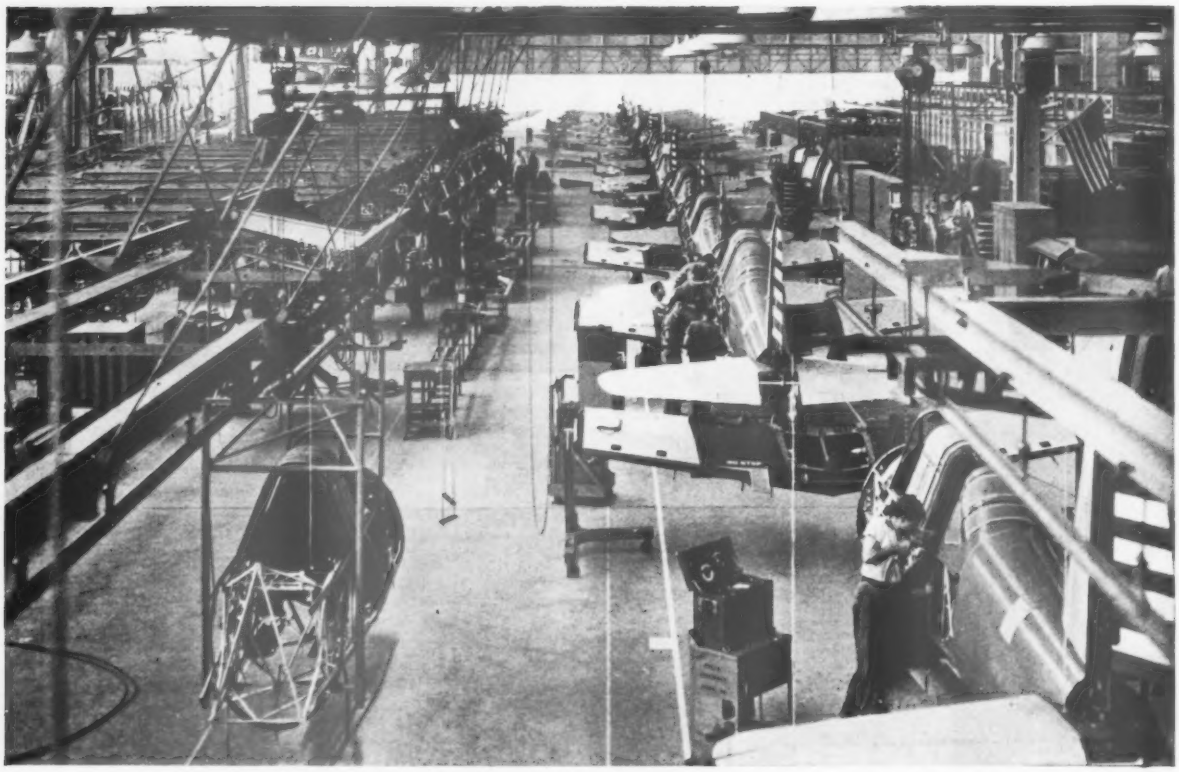
Another recent development that got its start at Wright Field is the four-bladed, constant-speed propeller on the Martin B-26 above. "Cuffs" on hubs were found to increase efficiency.

On the Wright Field test mount below, aeronautical engineers test new engines and propellers. Both are subjected to stresses far in excess of any normal flight maneuvers.



Two-bladed propellers, like those at Randolph Field above, now are relegated almost entirely to trainer use by the Air Corps.

The world's largest propellers can be tested on this Wright Field Propeller Section test rig, several of which now are being used.



Improvements from Experimental Engineering are added to these Vultee BT-15's on assembly line.

PRODUCTION ENGINEERING

The job of this group of engineers is to incorporate latest improvements in Army aircraft.

by Lieut. Col.
KENNETH B. WOLFE

Born August 12, 1896, in Colorado, Lieutenant Colonel Wolfe has been in Army Aviation since 1918. Command pilot, corps observer and engineer, he is chief of Production Engineering at Wright Field.

FACTORY buildings are rising rapidly, machine tools are being installed before their completion and production figures are mounting monthly as the nation's aircraft industry gets underway to manufacture the air armada Uncle Sam is ordering for national defense. Results are evident on every hand as men by the thousands—skilled technicians and laborers—pour into U. S. industrial plants.

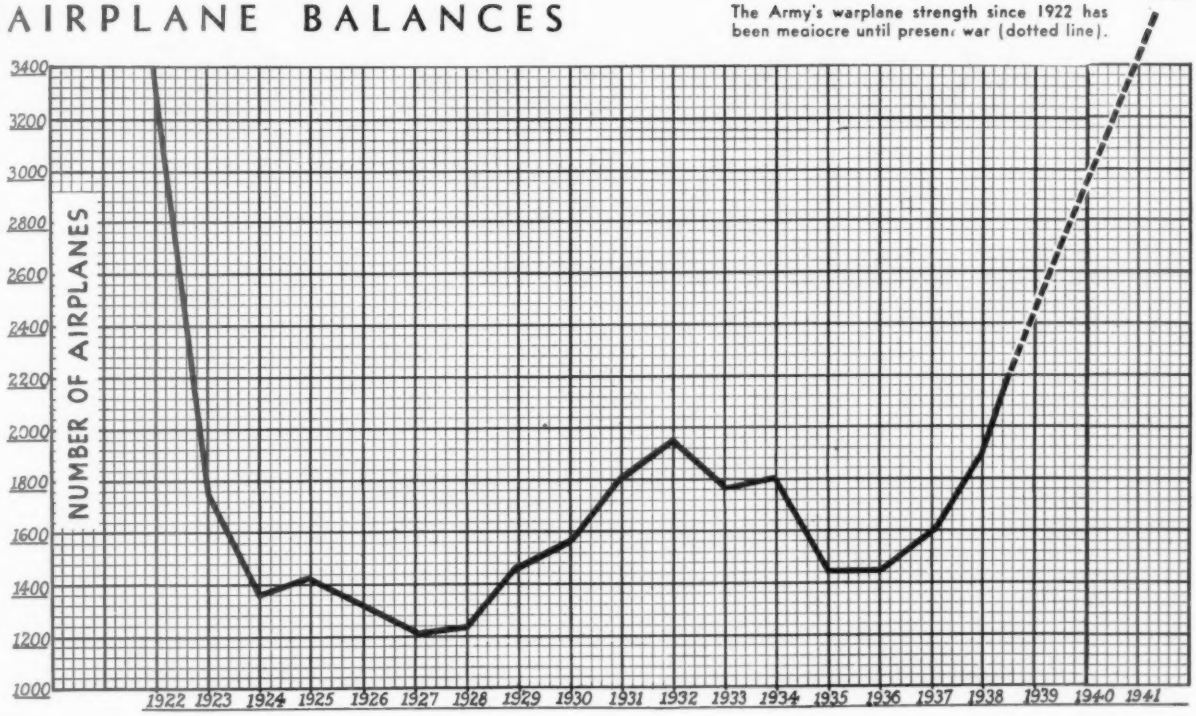
Focal point for this vast program of productivity as far as the Air Forces are concerned is the Air Corps Production Engineering Section at Wright Field, where skilled engineers and contract attorneys prepare contracts for purchasing the thousands of warplanes and vast supplementary equipment. From this specific branch of the Air Corps come technical experts who act as overseers at plants engaged in aircraft production or auxiliary factories with sub-contracts who supervise the details of contract, purchase and delivery and help speed production efficiency.

Air Corps purchases made by the contract section of Production Engineering for 1940 totalled $1,629,231,331, far exceeding combined purchases made in the four years preceding. Break that figure down into hundreds of individual contracts with industrial plants and you get an idea of the involved task of getting new planes "into the blue." Expansion of our Air Forces has been revised upward since 1939 when the 5,500 plane program was set up—and nobody knows whether the revisions are finished yet.

In 1939 Congress authorized purchase of 3,032 airplanes. Progress of the war in Europe, however, brought about drastic increases in the number of planes judged adequate for our hemisphere defense. This new program resolves itself into approximately 35,000 Army planes and 15,000 for the Navy. It also involves many headaches.

AIRPLANE BALANCES

The Army's warplane strength since 1922 has been mediocre until present war (dotted line).



At the outset of the procurement program it had to be decided whether to buy standard types which could be turned out rapidly or to order development type airplanes which were not far enough along to go into immediate mass production, but which were designed for improved performance over all standard types.

Advocates of standardization were met with the telling argument that rapid European developments in military aviation would render U. S. planes obsolete in very short order. The decision was finally made in favor of purchasing the newer development airplanes, some of which still were on the design boards. Facilities were arranged to speed new types through preliminary stages so that tests would be completed and they would be ready for mass production by the time additional plant space and machine tools had been provided and sufficient funds appropriated.

It was the time required to reach this decision that made production on our warplanes seem so slow. As new, improved fighters are pouring off assembly lines today it is apparent that the choice was a wise one. Now our planes are beginning to make their weight felt in the European conflict and are equal to and even superior to their counterparts in the RAF and Luftwaffe.

Inadequacy of firepower, lack of leak-proof fuel tanks and armor plate, were the main objections to the first American planes to reach Europe. These are all natural consequences of a philosophy in aircraft design which was seeking superior performance rather than formidable armament arrangements.

Wright Field observers—most of them production engineers—hurried to France and England in early 1940 to study guns and armor on the planes being used in combat. Their recommendations when they returned have resulted in increased firepower and more protection, even at the expense of speed and range on planes under construction for our air defense. These changes necessitated re-designing numerous parts, replacement of certain armament articles and design of additional equipment. All of these were problems for the Production Engineering Section, because they were directly concerned with the production airplane requiring modified changes in it. Instead of increasing ammunition loads in our warplanes, as the British did, our engineers chose to develop new corrective sights to improve gunnery and to make existing ammunition load more telling. Heavier caliber machine guns were installed, power turrets were applied, new leak-proof tanks were developed and additional guns were installed in our newest fighters and bombers. Shell-firing cannon provided still harder-hitting power. (For a more detailed account of these developments see story on armament elsewhere in this issue.)

Arming and armoring our planes resulted in slowing up aircraft production so that needed changes could be incorporated. Jumping into production on airplanes and engines of an experimental type was a serious problem. Although under control now it still presents serious difficulties. Production Engineering faces the task; changes have been made in its whole operating system.

Prior to the expansion period, the Army bought one experimental airplane, tested it, oftentimes to destruction, before ordering it in small quantities. The whole process took anywhere from one to five years. Now planes have been

(*Continued on page* 200)

Portable instrument tester illustrates part of Production Engineering job of keeping Army planes in use up to date.

MAINTENANCE COMMAND

by Brig. Gen. HENRY J. F. MILLER

A West Pointer, Brigadier General Miller transferred from Cavalry to Air Service in 1920. Born in New Jersey, September 10, 1890, today he is chief of Air Forces' new Maintenance Command at Wright Field.

AMONG the lesser-known, but most vital, functions of the Materiel Division at Wright Field is the housekeeping body known on the organization charts as the Maintenance Command. It does the same job for the Army Air Forces that the Quartermaster Corps does for the regular Army. Brand-new, established only since April 29, 1941, the Maintenance Command supersedes several older sections in the Materiel Division's complex set-up. It is charged specifically with Air Forces supply, maintenance, warehousing and transport between stations; and must provide amazingly fast service to fighting units anywhere in this hemisphere.

Under the supervision of the division's chief, Brig. Gen. Oliver P. Echols, the Maintenance Command consists of a headquarters staff and certain operating subdivisions. It has one flying branch: a transport wing based at Wright Field and four maintenance wings based near each Air Force Headquarters in continental U. S.

The Maintenance Command uses both military and civilian personnel. Commissioned officers command all units. All personnel at Command headquarters, wing headquarters, group headquarters, control depots and sub-depots are civilians. Transport wing and air depot group (mobile) personnel all are drawn from the Service.

Following standard Air Forces procedure, the transport wing is organized just like a combat wing. Transport planes, however, are not expected to enter a combat zone except to deliver supplies and get out as rapidly as possible under heavy escort. They are large air-freight craft with no defensive equipment.

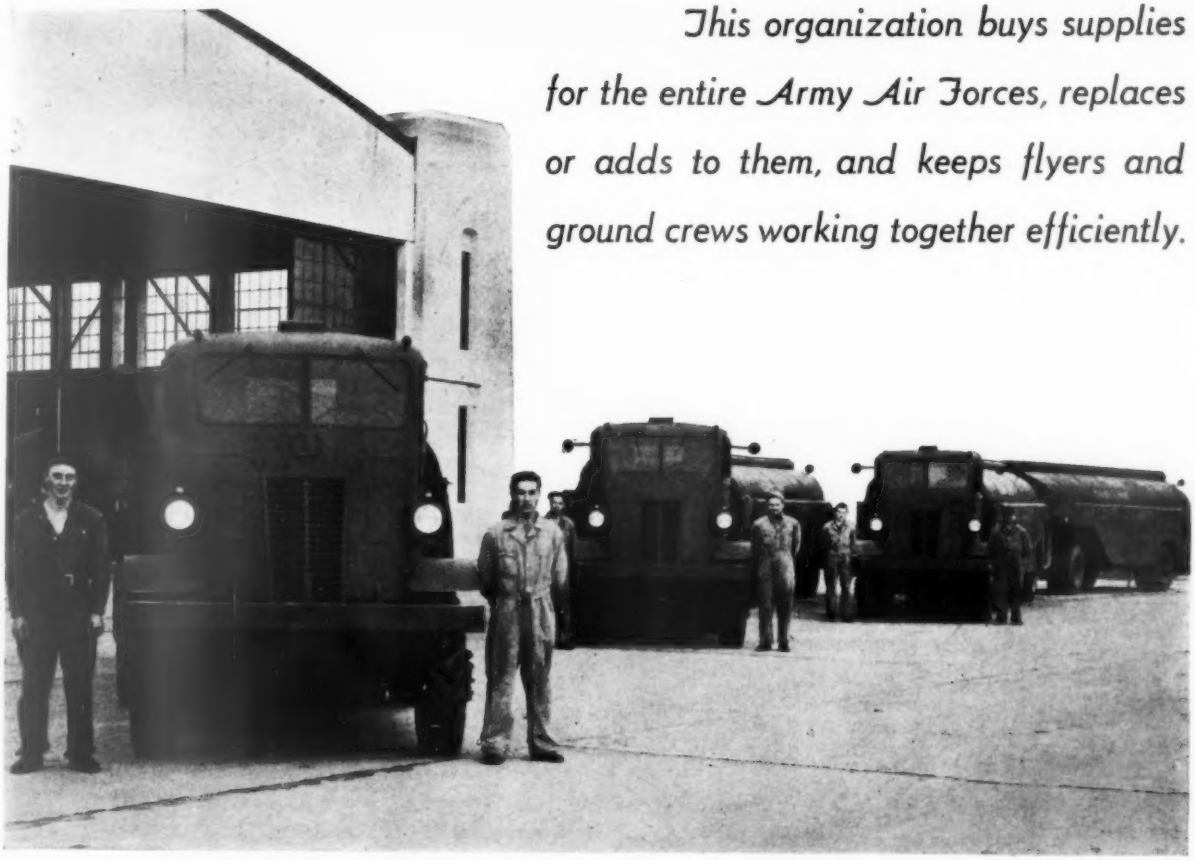
Within this framework of headquarters in each Air Forces area and at Wright Field, the Maintenance Command has organized the strangest airline in the world. It operates on schedule, boasts a faster running-time than any civilian airline and can carry tremendous loads. Furthermore, this airline flies on schedule from Wright Field to Panama; carries tons of Army mail on daily trips to Washington; and can fly a general or a generator to Alaska or Arkansas on a moment's notice.

It covers not only the continental U.S. but every point served by the Air Forces overseas . . . Greenland, Guatemala, Honduras, Hoboken and Hawaii. This particular phase of the Maintenance Command is covered more thoroughly in the cargo and transport article elsewhere in this issue. Nerve center of this vast service network is the spread-out warehouse and command headquarters at Wright Field. Directly subordinate to it are complicated air depots located at Fairfield, O.;

On hand in Maintenance Command storehouse is a supply of trainer engines. Orders are filled promptly and delivered by plane.

All kinds of airplane spare parts, including complete wings and tails, are stocked so rush orders can be dispatched immediately.

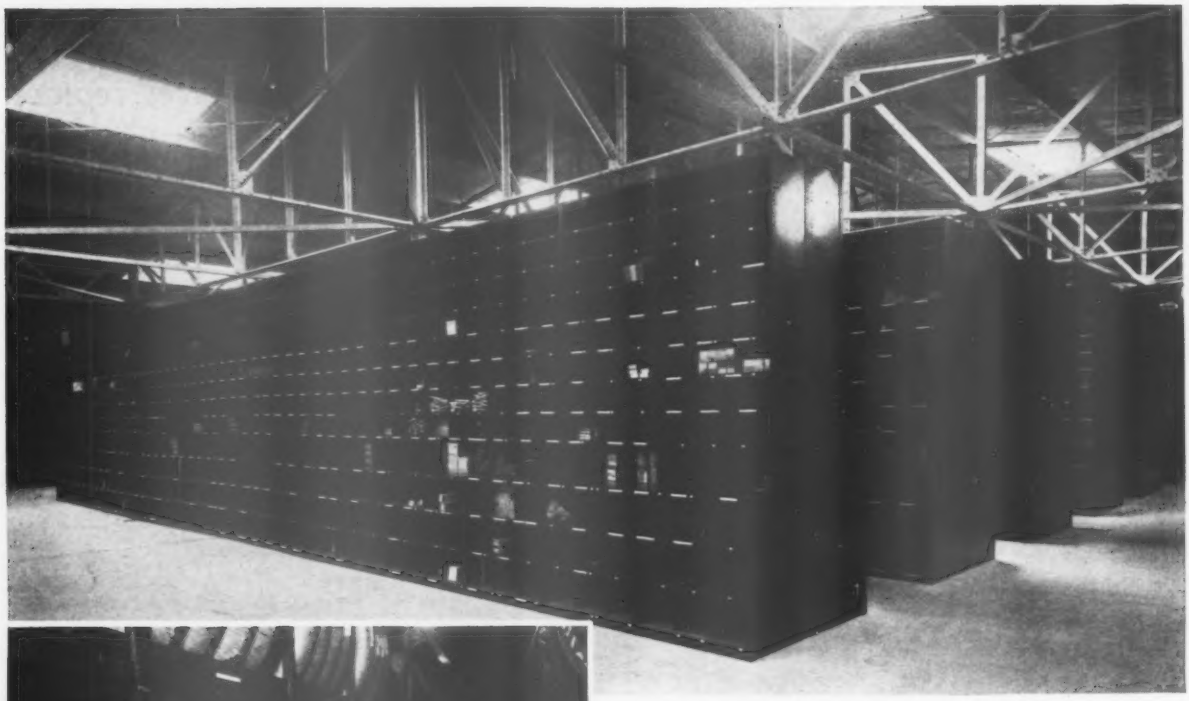
This organization buys supplies for the entire Army Air Forces, replaces or adds to them, and keeps flyers and ground crews working together efficiently.



One of the duties of Maintenance Command is to supply air bases with refuelling trucks. Before Air Corps buys such trucks they must be tested and approved by Experimental Engineering section.

Merely supplying Air Forces pilots is a man-sized job. Helmets, goggles, clothing and textbooks all must come from Maintenance.

At Randolph Field alone, nearly 1,000 aviation cadets must be supplied with such things as winter flight clothes and boots.



Typical of the supplies kept inventoried are the small hardware items above and airplane tire tubes (left). These pictures show representative sections of one of the Army's depots.

Middletown, Pa.; Sacramento, Cal.; San Antonio, Tex.; Ogden, Utah; Mobile, Ala.; and in Hawaii, the Philippines and Panama. Other depots are being constructed to add to the Maintenance Command's facilities. They will be located at Rome, N. Y., Wellston, Ga.; Oklahoma City, Okla.; and at other strategic points. One or more transport squadrons are stationed at each depot to haul extra priority freight shipments to Air Forces units in emergencies.

These depots are similar to regional warehouse facilities in a large commercial business. They are enormous storage buildings ranged around the edges of large air fields. There are factories and offices at each point, staffed largely by civilian personnel in the employ of, and under the command of, Air Forces officers. Working in the Patterson Field supply depot unit alone are more than 500 civilians and 10 army officers, figures closely paralleled at other air depots. They act as branch warehouses and repair centers; as factory branches for the construction of specialized equipment; and as accounting, procurement, distribution and transportation division points in the national maintenance organization.

Special storage facilities are necessary. Rubber must be kept in temperature-regulated hangars to prevent expansion, contraction, or rotting. Wing sections, elevators, ailerons and rudders must be kept in dark rooms so that the highly evaporative dope and painted surfaces will not warp the giant sections. Oil and gasoline requires underground vats. Special vaults prevent deflection of compasses and other intricate instruments. Great quantities of film are stored at each depot in cold rooms.

From them, supplies are issued to Combat Command tactical squadrons or any other Air Forces unit. They also supply the Air Corps' training schools. Each depot covers a surrounding area of states. Each has a set of initials which appear on each air freight package it sends out or receives. For instance, packages marked "F.A.D." are sent to Fairfield, O., warehouses and distributed to stations in North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Indiana, Michigan, Ohio, Kentucky and Tennessee.

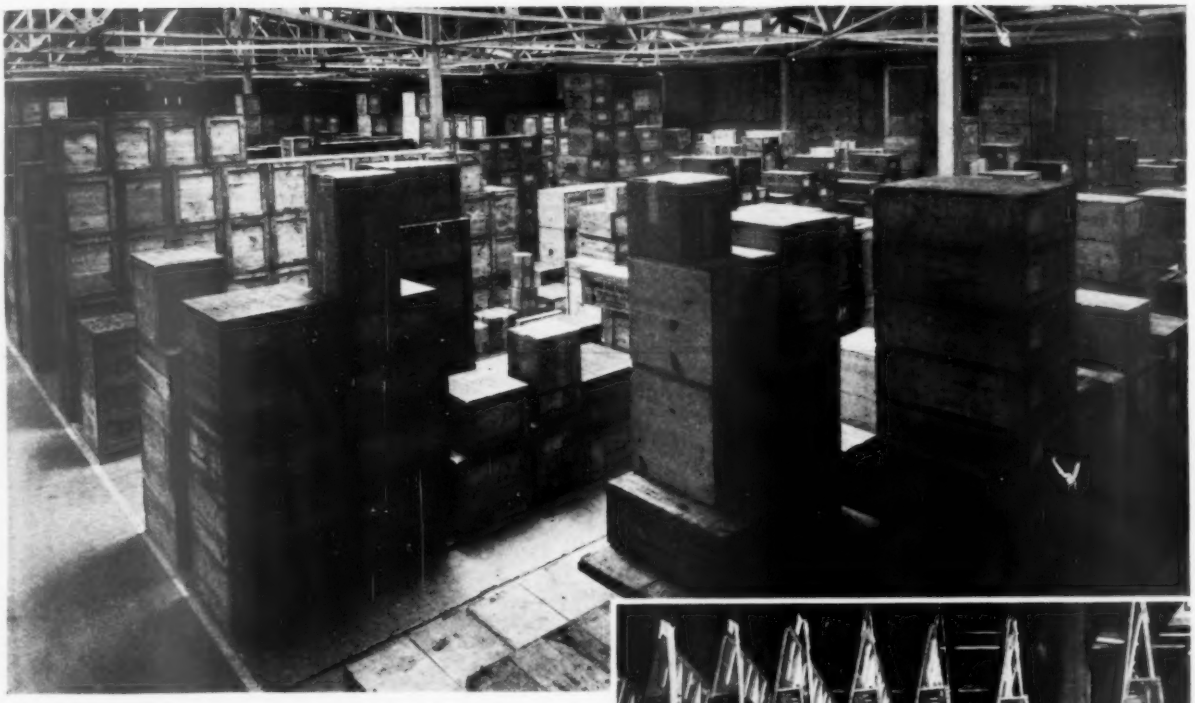
Middletown, Pa., is symbolized by the initials M.A.D. and serves the New England states, New York, New Jersey, Delaware, Maryland, West Virginia, Virginia, the new island bases being established at Newfoundland, Trinidad and Puerto Rico and supplies the big base at Panama.

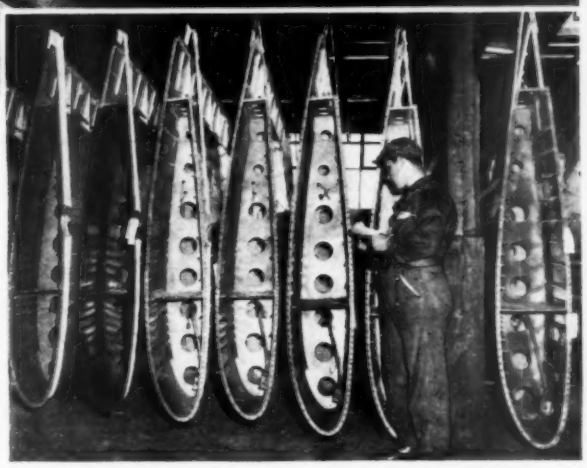
The Mobile depot's initials are Mo.A.D. It flies supplies to South Carolina, Georgia, Alabama, Mississippi and Florida. At San Antonio (S.A.A.D.) schedules are flown to stations in Oklahoma, Texas, New Mexico, Arkansas, Arizona and Louisiana.

Sacramento (S.A.D.) supplies California, Hawaii, Alaska and the Philippines. And Ogden, Utah, (O.A.D.) controls supplies sent to Washington, Oregon, Nevada, Idaho, Montana, Utah, Wyoming and Colorado.

To keep the thousands of inventory items straight and speed up handling, the Maintenance Command has assigned some of its field units certain items to handle. In this way the headquarters section hopes to develop special knowledge and skill in the personnel, so that they can answer any question apt to arise concerning articles they handle. All of these units are united into a separate Maintenance Command subsidiary called the Field Service Section. This section, in turn, is divided again into three groups—supply, maintenance and logistics and publications. In addition to the 500 or more workers stationed in the supply depot units at each of the various air depots, there are approximately 450 workers in the Field Service Section at Wright Field.

Going farther into the organization chart's fine print, we see that groups are divided into units, each of which handles only one or two items. One unit handles fuels, chemicals,





In the engine parts storeroom of Sacramento (Cal.) Air Depot (above) are crates of pistons, cylinders, valves and spark plugs. Always on hand, too, are replacement wings (right).

paints and lubricants. Another is charged with airplane parts: wing sections, landing gears, wheels, rudders, tail assemblies and a thousand other things. Command therefore is simplified; each group commander can hold his subordinate unit commanders responsible for the items in their lists, instead of having to know everything about each item himself.

Supply and maintenance organizations get supplies to Air Forces stations and maintain them. The third section, logisticas and publications, refers to a little-known policy of compiling and tabulating miles of statistics on the performance of every item in the Maintenance Command. The undertaking's magnitude requires a separate division of the Field Service Section to keep it up to date and accurate.

This latter section has no relation to the Air Corps Information Section. It handles no public releases, nor does it edit house organs. Its publications are highly technical engineering or tactical manuals for Air Forces officers' study. They concern such topics as the installation of a 37 mm. cannon or wing-flutter calibration in an interceptor at a 600 m.p.h. theoretical speed.

The term "Maintenance Command" and the necessity for dry, routine compilation of endless inventories sounds like an uninteresting job. It has, however, some interesting features. One of these is the mobile depot repair squadron attached to each Air Force area. This is a flying armada of mechanics in well-equipped transports. They have elaborate tools with which to do intricate repair work anywhere their ships can land. If a damaged plane is not an utter washout and if they can land close to it, they usually can get it back into the air. At Field Service Maintenance Branches—as described elsewhere in this article—they then can be completely repaired by the skilled metal workers, welders, propeller experts, machinists, pattern markers, aeronautical mechanics, electrical workers and radio experts on duty there.

Another Maintenance Command job which never becomes monontonous is the dispatching clerk's. He receives, at Fairfield alone, 600 railway carloads—about 33 *million* pounds—of merchandise a month. He is only one of eight such receiving clerks in the organization, which indicates that the Maintenance Command must find space for 264,000,000 pounds of incoming freight monthly, store it, issue it out to stations, transport it, maintain it after crackups and collisions, keep voluminous records on it and account for it to the Materiel Division. The Supply Branch also includes an organization to dispose of surplus properties—equipment no longer useful to the Air Corps, but valuable to other Government agencies.

Wright Field authorities say that about 10 carloads of freight a day are being shipped from each of the eight air depots to units within their control areas. For delivery to the various stations throughout these air depots' respective control areas, the latest trucks and trailers, freight trains and airplanes are used. Patterson Field has a fleet of four tractor-trailer freight hauling trucks doing this job. This number is being increased to nine as soon as the equipment is available. Other depots have about the same number. On orders necessitating speed, transport planes are of course employed.

The magnitude of the Maintenance Command's responsibility is shown by brief glimpses at inventory sheets. At Patterson Field, in one warehouse, are more than 700 engines, from 100 to 2,000 h.p., valued at more than $5,000,000. Prices vary from $8,000 to $18,000. A pilot receives complete winter and summer flying costumes. The nearest depot supply unit fits him out, depot tailors making necessary alterations. Total cost is about $250 per man for flying equipment. Multiply this by 150,000 pilots and you'll get an idea of what it will cost to equip an air fleet the size of ours. The total is something like $7,250,000 for pilots' equipment alone.

(*Continued on page* 178)

CARGO and TRANSPORT

Current Army transports are counterparts of the Douglas DC-2's and DC-3's used by the airlines.

All Air Forces supplies go by air if possible. To handle the job, the Army operates one of the world's biggest, busiest passenger and freight airline systems.

by Maj. MURRAY C. WOODBURY

Born in Vermont, "Woody" enlisted in Aviation Section, Signal Corps, in 1918, became a Cavalry officer a year later, returning in 1923. At 42, he heads 10th Transport Group.

EYES that gaze skyward these days and see a big transport plane's glistening silvery wings visualize well-to-do passengers and pretty hostesses in upholstered, soundproofed cabins. They assume the ship to be a luxurious airliner on a scheduled run. Often they are wrong. It would surprise groundlings to see inside a practically bare cabin with no seats or trimmings, filled with freight ranging from spark plugs to entire airplane engines; from fuselage parts to complete wing sections of small airplanes. Sometimes there are armed pilots and crews guarding shipments so valuable that ordinary means of transportation cannot be used.

This, then, is an Army transport squadron cargo airplane. Exploits of fast-flying pursuit ships and giant long-range bombers hold public attention. Cargo and transport planes are seldom in the news. Also in the background are the men who fly the cargo ships and the ground organizations that keep them in the air.

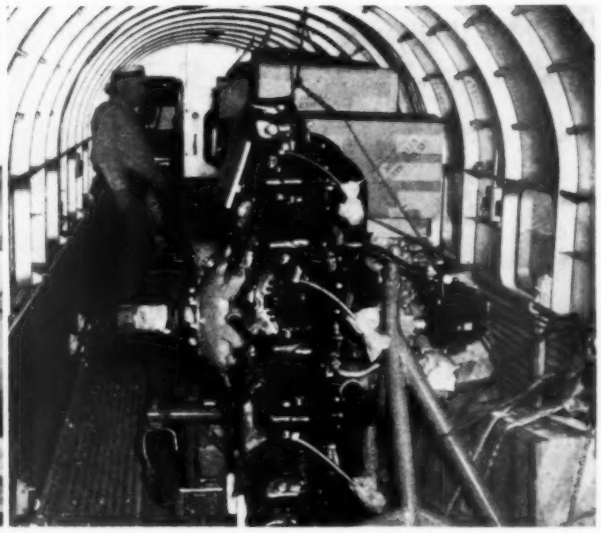
But the transport squadrons make up the largest air freight line in the nation—a freight line operated by Uncle Sam to keep Air Force tactical units throughout our possessions serviced, supplied and ready for action at all times.

Airplanes, no matter how many of them are on hand, are useless unless they can be kept flying. It takes almost two auxiliary planes to keep one combat plane in the air. Planes depreciate rapidly under the gruelling conditions of combat maneuvers or actual warfare. Thus, it is important that spark plugs, engines, wing sections, rudders, elevators, wheels, tires, cowlings, machine guns, bombs, bomb sights, ammunition, rivets, seats, armor plate and hundreds of other vital accessories are available instantly to tactical units when needed.

The Air Forces have organized transport squadrons because of the need for speed in emergencies. In the early Air Corps days cargo airplanes were available, attached here and there to various Air Corps stations. They were flown on freight-carrying missions only when there was an emergency. The organization was widespread and had no central headquarters. Only in recent years has the Army seen the real value of cargo shipments by air.

The first cargo ship so designated by the Air Corps was the C-1, a biplane resembling World War ships. It was a Douglas, powered by a single 450 h.p. Liberty engine. Its useful load was low, speed was slow, range was short and safety questionable. Compared with the Douglas C-47 transport planes now in use, it offered a decided contrast. Today's ships are monoplanes powered by two air-cooled radial engines developing 1,200 h.p. each. Their useful loads are high—nearly two

Army cargo planes all have special freight-loading doors and are rapidly convertible to either freight or personnel loads.



One Army transport can carry several airplane engines and accessories at once. Many engines now are delivered to Army by air.

tons of freight plus crew and full equipment; cruising speeds approach 200 m.p.h.; maximum range is 1,500 miles. Minimum maintenance is necessary. They have a very high safety record. A newer plane called the Curtiss C-20, not yet in use, will have the same performance and carry over seven tons of freight.

Transport service history dates back to the time when the War Department was organizing GHQ Air Force. In 1935 the transport squadrons became a separate part of the Air Corps. The 1st Transport Squadron was organized at Patterson Field, Fairfield Air Depot, near Dayton, O. Since that time the 5th, 9th, 11th, 13th and 63rd Headquarters Squadrons have been activated there. Other squadrons have been formed at air depots located at Middletown, Pa.; Sacramento, Cal.; and San Antonio, Tex. Plans already have been laid to establish additional squadrons at Ogden, Utah, and Mobile, Ala., as soon as these two new air depots are completed.

The 10th Transport Group was the original organization of transport squadrons into a larger unit. It consisted of one squadron of two Bellanca C-27's attached to each air depot. In 1936 these planes were augmented by two Douglas DC-2's (called C-33's in the Air Corps) assigned to each squadron. In 1938, payloads and speed were increased again with the addition of 39 Douglas C-39's (modified DC-3's). Now transport groups are stationed at each air depot.

Transport units are established entirely separate from the Combat Command. However, maintenance of the tactical squadron airplanes is primarily a transport group responsibility.

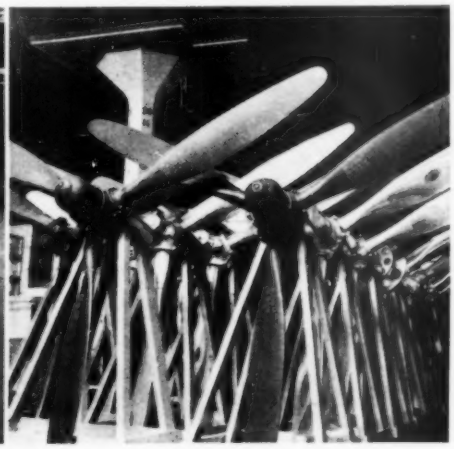
Jurisdiction over Air Corps depots and the activities of base fields in Alaska, Puerto Rico, Hawaii and the Philippines is directly in the hands of the Chief of the Materiel Division, Maj. Gen. Oliver P. Echols, stationed in Washington in the Office of the Chief of Air Corps.

To relieve pressure on Wright Field's command—which is badly over-worked with defense contracts, engineering and experimental development, not to mention growing problems in procurement presented by new defense plans—a new division has been established at Patterson Field, Fairfield, O., known as the Maintenance Command, under Col. H. J. F. Miller, who controls maintenance and supply needs of all Air Corps depots throughout the U. S. and its possessions, including all new bases leased from Britain.

Part of the Maintenance Command is the 50th Transport Wing, which is based at Wright Field under Lieut. Col. F. S. Borum. This wing commands all activities of the six transport groups at the air depots in continental United States. Each group, in turn, is composed of three squadrons. The present organization tables for a transport squadron call for 13 cargo airplanes, 40 officers and 161 enlisted men. Twenty of these officers must be first pilots. That means they must have instrument ratings and other qualifications comparable to first pilots on commercial airlines. Many of them are reserve

Below is a typical Army store room of supplies awaiting shipment by air. Every conceivable item, from pencils to whole wing sections, makes up a typical load.

Important to Army squadrons is a constant supply of propellers deliverable by plane.



THESE CARGO PLANES HELPED PIONEER

Fairchild C-8.

Fokker C-7.

officers who, before being called to active duty, were airline pilots. A present shortage of first pilots is being remedied as rapidly as possible. It is this shortage of skilled manpower and planes which today limits operations.

The shortage of transport airplanes, according to the latest information, will soon be remedied. The Army is to acquire 600 new, modified cargo planes of the same type now being flown by the airlines. These ships are scheduled for delivery this fall. In time of emergency the Government can utilize the air lines' equipment, although this move probably never will be necessary. There are 350 airliners now in use by commercial airline companies. These ships, with their interiors stripped, could be converted easily into freight transports. There also are some other cargo airplanes of modern design at various technical schools and staff headquarters which could be transferred to transport groups.

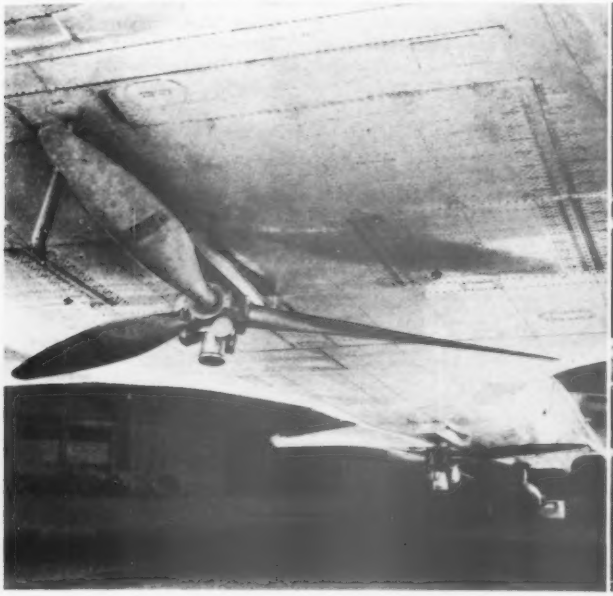
Since their beginning in 1935, the transport groups have been doing the highly essential job of carrying supplies and sub-assemblies urgently needed by the tactical squadrons. They are being called upon to carry more and more pilots from one field to another; to fly inspection personnel to district offices; to conduct flights for Congressional inspections; and to expedite delivery of important parts such as engines, rudders, etc. Their post duties include removal of injured soldiers and civilians to hospitals and delivery of serums and medicines to isolated areas.

Recently the planes at Patterson Field have flown daily mail runs between Wright Field and Washington, carrying sealed orders and contracts concerned with the nation's big defense spending program. For 16 days just after Congress okayed the President's Air Forces budget, transport planes carried contracts totalling as much as $126,000,000 a day to aircraft manufacturers throughout the country. In 1940, more than 450 West Point cadets were flown in a 15-plane formation from West Point to Langley Field, thence to Wright Field and return to West Point in Air Corps transports. While in the air, the cadets were instructed in elementary navigation and airplane flying characteristics. They were allowed to sit in the co-pilot's seat and were given rudimentary instruction in the 150 control gadgets in these planes. Their papers on navigation and ground speed problems had been prepared by the West Point Air Corps detachment under the direction of Maj. John M. Weikert, commanding. They were graded by the pilot personnel. Object of this tour was to interest the cadets in selecting the Air Forces for their branch during their service careers.

In conjunction with the infantry, the transport squadrons are aiding the development of the parachute battalion at Fort Benning, Ga., carrying men aloft for parachute-jumping practice. This practice in formation flying enables the pilots to fit more easily into bombardment and other combat formations. Many officers believe that young pilots just out of school receive training in transport groups which is unparalleled elsewhere in aviation. They immediately learn blind flying and instrument "let-downs" in any sort of weather.

Transport groups at the various air depots operate within specified control areas. The depot at Sacramento services all Air Forces units in Washington, Idaho, Montana, Wyoming,

One method used to transport propellers when a cargo plane's interior is filled is to bolt them underneath the fuselage.



New Allison engines are picked up at the factory by Army cargo planes and flown to aircraft factories building pursuit ships.

THE ARMY'S PRESENT TRANSPORT SYSTEM

Bellanca C-27C.

Lockheed YIC-37.

Oregon, Utah, California and Nevada. San Antonio Air Depot is responsible for units in Arizona, Colorado, New Mexico, Texas, Oklahoma, Arkansas and Louisiana. Patterson Field's control area consists of Alabama, Mississippi, part of Georgia and Florida, Tennessee, Kentucky, Ohio, Indiana, Michigan, Minnesota, Wisconsin, Illinois, Missouri, Iowa, Kansas, Nebraska and South and North Dakota. Middletown Air Depot covers Maine, Vermont, New York, New Hampshire, Rhode Island, Massachusetts, Connecticut, North Carolina and parts of Florida and Georgia. Control areas for the two new depots have not yet been selected, but it is probable that a portion of older depot areas will be divided between them.

Freight carried in Air Corps transport planes is classified in three ways: ordinary freight, priority freight and extra priority freight. Because of equipment and personnel shortages, only extra priority freight is being handled at present. Each classification covers specific articles. Office supplies and standard airplane parts go as ordinary freight unless urgent need for them necessitates an extra priority rating. Generally these items need not be shipped by air. To get them to the various fields within its control area, the Army has assigned heavy trucks and trailers to each transport group. They are maintained, serviced, garaged and driven by members of the transport squadrons.

Priority freight consists of supplies or parts needed by combat squadrons to keep planes flying. Included are parts to repair planes recently damaged. Personnel to aid in the repair of planes forced down go with the repair parts to the scene.

Extra priority freight covers plane parts furnished by the Government and needed by manufacturers to complete their orders. Transport outfits are often called upon to carry engines to airplane factories across the continent so that lack of power plants does not halt production. Items classified as extra priority freight are rushed to their destinations as quickly as possible.

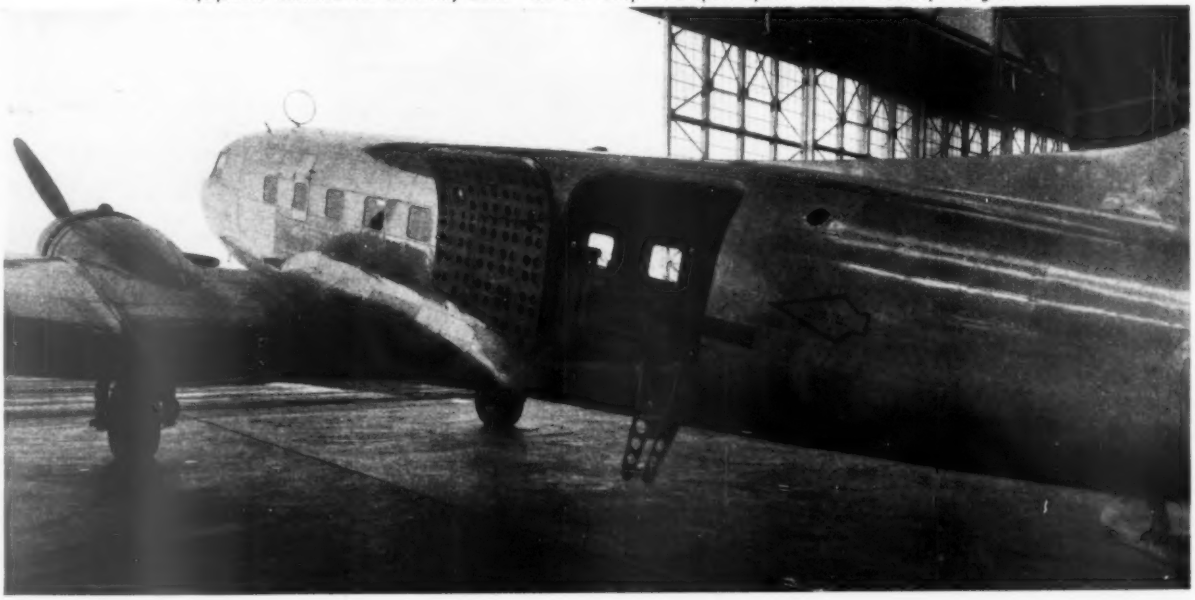
Freight shipments go out on regular "wing scheduled" flights between depots, or local or "group scheduled" flights to fields within the control areas. Two types of shipments are made from one air depot to another: inter-depot flights, as from Patterson Field to San Antonio, or from Middletown to Mobile; and intra-depot flights, such as freight trips from a depot to fields within its control area. An example would be a flight from Patterson Field to Selfridge Field, Mich., or from Middletown to Langley Field, Va.

There are also regularly-scheduled flights from various depots to the Panama Canal Zone and to Puerto Rico. Every Saturday there is a flight from Patterson Field to Panama via San Antonio, Brownsville, Tex.; Vera Cruz, Mexico; Guatemala City, Guatemala; Managua, Nicaragua; and the Canal Zone. When needed, there is an extra flight from Middletown, Pa., Air Depot to Puerto Rico via Miami and Camaguey, Cuba. Sacramento Air Depot sends a flight when necessary to fields in Alaska via Seattle, Juneau, Ketchikan, Anchorage and Fairbanks, Alaska.

Tracing a shipment is interesting as an illustration of the transport wing's operations methods. Let us imagine that a pursuit group at Selfridge Field, near Mt. Clemens, Mich.,

(*Continued on page* 200)

Through the wide doorway of this Sacramento Air Depot transport can be seen cases of supplies and equipment destined for an Army base. The Air Corps' transport system will be country's largest.



AIR BASES

Without complete, well-equipped bases, an air force is helpless no matter how great its striking power.

by Col.
FRANK M. KENNEDY

Born in Illinois July 10, 1896, Colonel Kennedy joined Infantry in 1908, changed to Air Service in 1917. He is graduate of Air Forces tactical and engineering schools, and assistant to Chief of the Air Corps.

THE present world emergency is forcing the United States and its hemisphere neighbors to pioneer new air frontiers. The milestones of this trek over the skyways are the air bases springing up in all parts of America's potential field of action.

From the Arctic Circle to the South American hump and from the islands of the Atlantic to the remote and lonely coral atolls of the Pacific, the firmness and security of American air defense is measured by the size, the strength and the location of its air bases. In all parts of the United States and its territories new air bases, stations, depots and training fields are in process of construction or enlargement. There is no more vital or colorful phase of American defense than this establishment of new defense frontiers and outposts for protection of human liberty and the American way of life. Our acquisition of base sites in Newfoundland, Bermuda, the West Indies and on the British Guiana coast of South America, is at once an opportunity and a challenge—an opportunity to push a little farther from our threshold the menace of aggression; a challenge to American energy and spirit.

The air base is air power's foundation—the eagle nest. The modern air base is much more than merely an airdrome. It is today an area, sometimes many miles in extent, in which there may be many airdromes to which the air force based there may be scattered. Peacetime airdromes, easily seen from the air, advertise their presence to all who fly. This is at once a peacetime advantage and a wartime peril. In time of war, the combat squadrons must scatter and the peacetime airdrome expands into a wartime air base area.

The air base must include not only landing facilities, but also maintenance and repair shops, warehouses, gasoline storage and servicing facilities, bomb and ammunition depots, quarters for combat and maintenance crews, messing and recreational facilities and other essentials. There may be bombing and gunnery ranges, night flying practice areas and classrooms. There probably will be elaborate radio and wire communications systems, radio homing devices, instrument landing facilities and weather observation stations. Around the whole may be a far-flung network of aircraft warning posts as a part of the vital base area's defense mechanism. The administrative personnel, the headquarters organizations, the parachute, photographic, signal, ordnance, quartermaster and other activities must be housed. There will be first aid and hospital facilities.

Providing bases for the Army's expanding air strength has become a tremendous undertaking. Previously the law required that all cantonment type construction, which of course included air base construction, should be done by the Quartermaster Corps. The burden became too great for a single organization, however, and, on the War Department's recommendation, Congress has authorized its division between the Quartermaster and Engineer Corps.

Construction of cantonments, airdromes and other facilities required by the Air Forces, other than a few projects far ad-

Modern warplanes need more than just landing space. Bases like Scott Field (below) must be designed to accommodate any plane the Army has and also must have facilities to handle any servicing.

Far different from the commercial airport, the military air base must be able to accommodate whole squadrons of big, heavy airplanes. Typical is March Field (above), base for bomber and pursuit units.

vanced when the new system went into effect last September, has been transferred to the Corps of Engineers. This includes work at the new Atlantic bases acquired from Great Britain. Under the division of construction duties, the Quartermaster Corps is handling a program of more than $1,000,000,000 worth of construction and the Corps of Engineers is in charge of $700,000,000 worth.

Location of a new air base is decided by strategical considerations. Bases are located in the paths of any conceivable attack from any direction, whether by way of Alaska, Greenland and Newfoundland, the South Atlantic or the Caribbean.

The general location decided upon, a board of experienced officers is sent into this area to select a specific site or sites, taking into consideration local limitations of terrain, transportation and accommodations for men and matériel. The necessary land then is obtained by gift from city or county governments in some cases, or by purchase or condemnation. The terms of acquisition are approved by the Judge Advocate General's Department.

Meanwhile, preparation of detailed plans for the landing area, buildings and other facilities is undertaken by the Air Corps' buildings and grounds division, with necessary technical personnel's assistance. The completed plans are turned over to the Corps of Engineers, which awards the necessary contracts for actual construction, grading, paving and other work.

While construction is in progress, the Air Corps begins the organization and training of the air and ground units which will man the new base. By the time the Corps of Engineers has the base ready, the air and ground personnel usually is ready to take over, adding the new base to the nation's operational defenses. On May 18, 1941, for example, the War Department announced that 20 fledgling units of the GHQ Air Force (now the Combat Command) had completed basic training and were being transferred to permanent stations to begin unit training. The 20 units, recently activated, had reached a training stage which permitted their separation from parent organizations. Five older organizations also were being transferred to new stations.

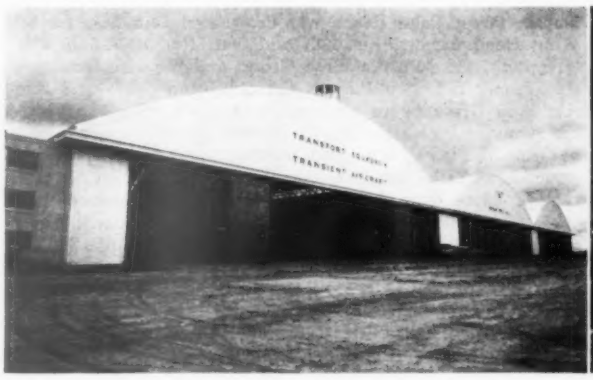
All but two of the fields to which the units are moving are new, marking another stage of the Air Forces' expansion program, the War Department explained. Five more air fields then were located at Fort Wayne, Ind.; East Baton Rouge, La.; Meridian, Miss.; Bangor, Me.; and Manchester, N. H.—scheduled to be ready between June and August of this year.

The transfers involve approximately 11,000 men, organized into eight bombardment groups, eight reconnaissance squadrons, four headquarters squadrons, four pursuit groups and an air base group. Three of the new units were created on February 1, 1940, and the other 17 in January and February of this year. Many began sending advance detachments to their new quarters as early as May 4 to prepare facilities for the rest of the commands.

Discussing bases in a recent radio address, Maj. Gen. Henry H. Arnold said: "The expansion of the Air Forces has made necessary the establishment of many additional stations and bases for the operation, repair and supply of new units. Whereas two years ago there were but six stations occupied primarily by Air Forces units, we have to date selected approximately 50 new sites for stations. We also are adding two large Air Corps supply and repair depots to the four that existed previously and have established two new training centers to augment the training formerly given at Randolph and Kelly Fields in Texas."

The Air Forces expansion plan, based on legislative action by

Hangars must be inconspicuous from the air. In wartime, planes are scattered around the field to minimize damage from air raids.



Civil airports like that of Orlando, Fla. (below) could handle many Army planes. In war, though, all markings would be hidden.

Army planes now can operate from many auxiliary fields at night with mobile lighting trucks like that above and below.

the 76th Congress, called for 256 squadrons. Immediate provision for a great number of additional airdromes and bases became imperative. After reorganization the Air Forces decided to establish more than 30 temporary air bases, locating them on civil airdromes which had sufficient landing area and were situated reasonably close to towns of sufficient size to afford the 400 or so houses required and suitable for the housing of married officers and non-commissioned officers. These temporary air bases generally are large enough to house a group of four squadrons.

Within the continental United States, major new bases have been located facing the danger points from which might come conceivable invasion attempts. Against the northern trans-Atlantic Great Circle route, with its stepping stones in Iceland, Greenland and Newfoundland, the Army has opposed the new Northeast Air Base near Springfield, Mass. An approach by way of the South Atlantic and the Caribbean would be confronted by the Southeast Base at Tampa, Fla., and numerous other South Atlantic states airdromes. Should the attack come by way of Alaska, there is a major air base at Tacoma, Wash., and others in the Pacific Northwest. Against the threat of carrier-borne air attacks there are such major bases as Langley Field, Va.; Mitchel Field, N. Y.; March Field, Riverside, Cal.; and Hamilton Field, Cal. Behind these are other inland bases, the supply bases and depots and the training bases.

Except for Army air bases in Hawaii, the Philippines and the Panama Canal Zone, there were virtually no other important Army air installations outside the continental United States prior to the present emergency. This lack of outlying bases, a grave weakness in our defenses, now is being remedied by rapid construction of bases and airdromes for the Army and Navy in Alaska, the Aleutian Islands, the Pacific islands beyond Hawaii, Newfoundland, the West Indies and British Guiana. The possibility of still others in Central and South America is dependent on the growing hemisphere defense policy.

The new air base program got under way in 1939, after Congress had appropriated an initial $300,000,000 for the air defense program, with $62,000,000 allocated for constructing five new air bases and for enlarging and improving existing Air Forces stations. These funds made possible a commencement of work in Alaska and Puerto Rico and strengthening of the Panama and Hawaiian installations.

Army boards were sent out to examine proposed base sites in Alaska and Puerto Rico and to collect information in Panama and Hawaii to determine whether new bases should be established there or whether effort should be concentrated on the enlargement and improvement of existing facilities. The studies included location of defense installations to protect the bases against sea or land attack. Ground units already have been sent to Alaska, Newfoundland, Bermuda, Trinidad, Puerto Rico and other of the new air base sites for permanent stations.

In August, 1939, then-Secretary of War Harry H. Woodring personally inspected the Panama Canal Zone. He reported that air force and antiaircraft installations in the Zone must be greatly strengthened. Movement of airplanes and antiaircraft troops from the United States to the Canal Zone began the same month.

In September, 1940, the War Department announced reorganization of existing air base squadrons into 24 new air base groups, to create units more easily administered on field duty. The groups were composed of three squadrons each, resulting in a 300 per cent increase in the number of such squadrons. Each group now consists of a base headquarters and headquarters squadron, an air base squadron and a matériel squadron. At bases where more than one combat group is located, the air base group is reinforced by an extra matériel squadron for each combat group. Increased mobility is afforded through creation of the separate, relatively small matériel squadrons, which can be detached from the base group to provide personnel for operation of temporary airdromes. The reorganization also provided for special air base groups for assignment to the training bases.

During the same month, the War Department announced that sites in the vicinity of Augusta, Ga.; New Orleans, La.; Tallahassee, Fla.; and West Palm Beach, Fla., had been selected for Army Air Corps tactical unit stations. It was planned, upon completion of housing and other construction, to station one pursuit group at Augusta, a bombardment group at New Orleans, and two pursuit groups at West Palm Beach. Twenty-first Wing Headquarters and the 38th Air Base Group (Reinforced), in addition to the 30th Bombardment Group (Heavy), were assigned to New Orleans a little later in the month. West Palm Beach was designated as a base for 8th Wing Headquarters, the 49th and 50th Pursuit Group (Interceptor), the 40th Air Base Group and the 14th Transport Squadron. The 53rd Pursuit Group (Interceptor) and 22nd Air Base Group were assigned to Augusta. To Tallahassee the Army assigned the 23rd Composite Group (to be replaced at Orlando, Fla., by a medium bombardment group when construction at Tallahassee was completed) and the 25th Air Base Group. More than $5,000,000 was allocated to construction at these four southeastern bases. The announcement was typical of many similar announcements in succeeding months.

Little more than a week later, the War Department reported that sites for new Air Forces stations had been selected at Bangor, Me.; Manchester, N. H.; Charlotte, N. C.; Atlanta, Ga.; Jackson, Miss.; Boise, Ida.; Bowman Field, Ky.; Albuquerque,

(*Continued on page* 196)

DOUGLAS B-18A

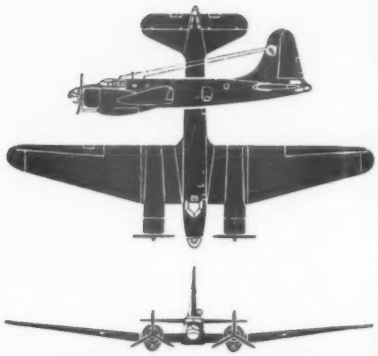
FOR IDENTIFICATION

As more and more emphasis is placed on military aviation, it is important that soldiers, sailors and civilians alike be able to recognize airplanes of their armed forces. The following silhouettes identify all current Army aircraft.

BOMBERS

BOEING B-17D

DOUGLAS A-20A

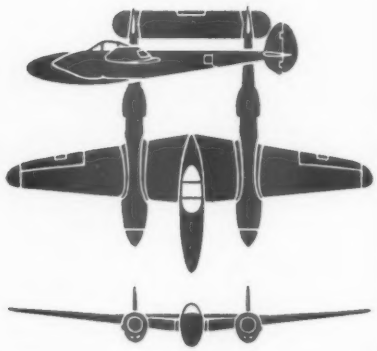


DOUGLAS B-23

PURSUITS

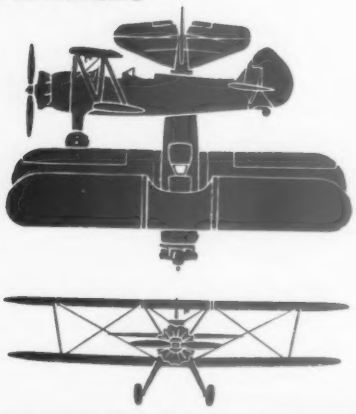
REPUBLIC P-35

CURTISS P-36A

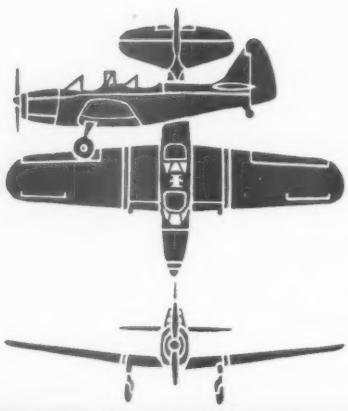


LOCKHEED P-38

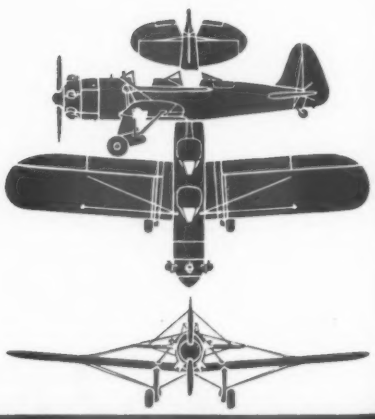
TRAINERS



STEARMAN PT-17

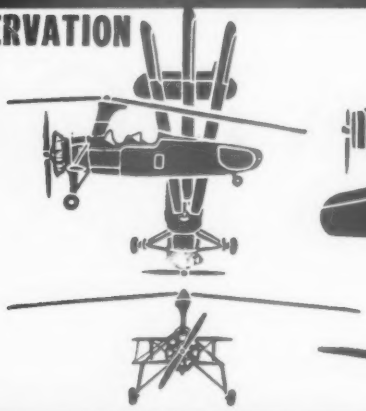


FAIRCHILD PT-19

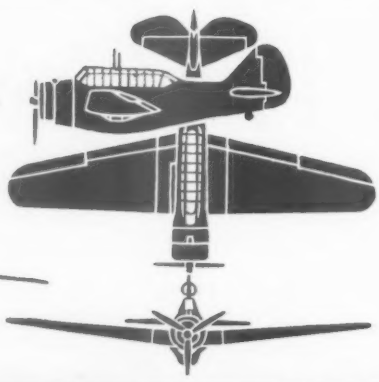


RYAN PT-21

OBSERVATION

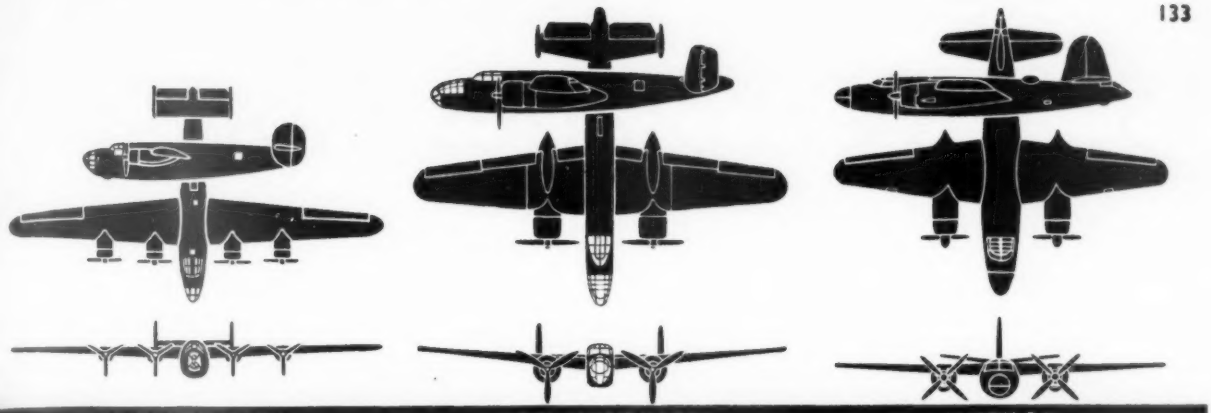


KELLETT YG-1B

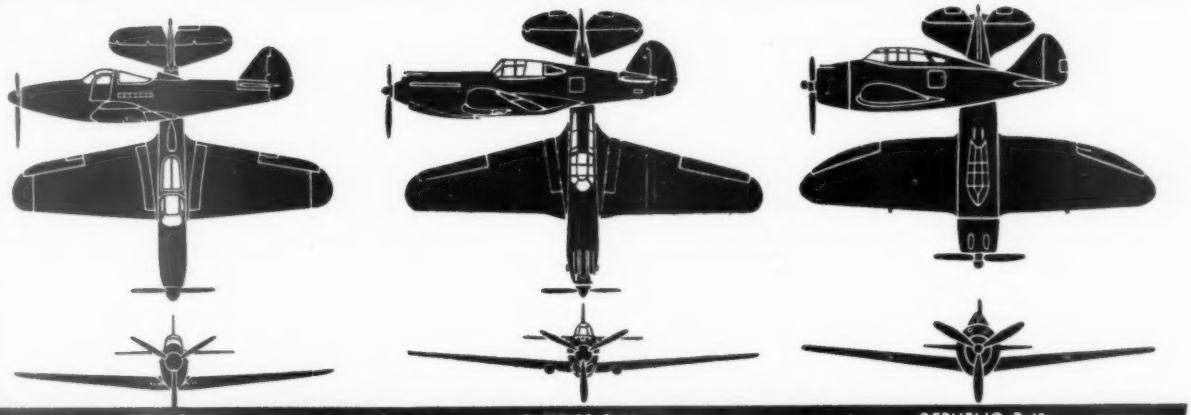


NORTH AMERICAN O-47A

STINSON O-49



CONSOLIDATED B-24 | NORTH AMERICAN B-25 | MARTIN B-26



BELL P-39 | CURTISS P-40 | REPUBLIC P-43

NORTH AMERICAN BT-9 | NORTH AMERICAN BT-14 | VULTEE BT-15

RYAN YO-51 | CESSNA AT-8 | BEECHCRAFT AT-7, F-2, C-45

U. S. Warplanes Abroad

Proof that our Army knows its warplanes are the American aircraft fighting in the European war today.

by Brig. Gen.
MARTIN F. SCANLON

A military pilot and corps observer, General Scanlon recently returned from several years' duty as U. S. air attache in London. A Pennsylvanian, the 52-year-old general holds Distinguished Service Medal.

AMERICAN airplanes, hundreds of them, are playing a vital part in the titantic struggle abroad today, although as a nation we are still at peace. Designed by American engineers and built in our own factories by our own workmen, American-made aircraft of every type are proving their worth patroling the desolate coasts of Norway and Iceland, the broad expanse of the Atlantic, ferreting out submarines and surface craft in the English Channel and battling the invaders over London. In Canada, over Germany, in the Near East, South Africa, Australia and New Zealand aircraft and motors from New York, Maryland, Connecticut, New Jersey, Ohio and the West Coast are strengthening the effort of the Allied armies. Their weight in the scales of battle grows heavier week by week.

The purchase of airplanes outside Great Britain was in itself a radical departure from British policy. But the Munich Pact showed clearly the appalling need and British and French air missions both crossed the Atlantic to place orders for such types as they could get for adaption to their own needs. The conquest of Poland further demonstrated the necessity for accelerating the tempo of production and planes for Britain were given priority over even our own air forces in the effort to make up for lost time. Even this effort obviously was not enough and some of our own Army and Navy planes were declared surplus and sold back to manufacturers for resale to the Allies. The culmination of these events after the fall of France was the present system of sharing our output with Great Britain under Lend-Lease Act. This policy has greatly speeded delivery of American-built craft, whether shipped by boat or ferried by air. Deliveries of planes to England will reach a peak by 1942 which may make them a decisive factor in the present conflict.

When the first British purchasing mission came over to survey the possibilities of acquiring planes in the United States, selection was limited, at least so far as purchases in large quantities was concerned, to only two types, the speedy long-range Lockheed commercial transport, and the standard training plane manufactured by the North American Aviation Company and widely used by our own services. The reasons for this were easy to understand. The Lockheed transport was already in production and would need comparatively few changes to make it adaptable for use as a bomber or long range reconnaissance plane. In order to train the great number of pilots required by the expansion of the Royal Air Force, it was necessary to secure a great many transitional, or advanced trainers. As the only suitable British plane of this type was not in production, and would not be in production in quantities for some time, it was decided to contract for the North American advanced trainer, known to us as the AT-6, and renamed by the British the *Harvard*.

Interesting to note is the fact that several hundred of each of these two types were ordered in 1938 and deliveries started late in 1939 ahead of schedule which greatly impressed the British. They have proved so satisfactory that additional orders were placed and deliveries will probably continue for some time. The Lockheeds, renamed the *Hudson* by the British, were found to be admirably adapted to long range patrols. A turret with two .303 caliber machine guns has been mounted on the topside of the fuselage for protection from attack from the rear and racks for bombs large enough for effective use against submarines and small surface craft have been fitted under the wings. Assigned to the Coastal Command of the RAF, where they are spoken of most enthusiastically, they are on daily patrol between England and Scotland and Norway and Denmark, criss-crossing the North Sea on their constant vigil against invasion. It may well have been one of these craft which spotted the Bismarck in the harbor at Bergen before her break for the Atlantic.

The North American trainer is by now probably the most widely used plane of its type in the flying schools of the Empire. The Miles *Master* advanced trainer, which was scheduled to fill the needs for advanced work was not in quantity production at the time the original order was placed, and the *Harvard* was intended as a stopgap. The Miles trainer has not yet reached the quantity production stage and the American type is not only filling requirements in flying schools in Great Britain but is being used in schools in Canada, Australia, New Zealand and South Africa. A plant to manufacture them is now in production in Australia.

As a result of the crisis which developed in Europe during the Spring of 1940 our Navy turned over to the French a quantity of SBC-4's, the old Curtiss *Helldiver*. France fell before delivery was completed and with the exception of the last five, which went to the British, these planes are now disintegrating at Martinique.

The Army also turned over to the British by the resale method 93 A-17A's, a Northrop attack plane of an obsolescent type. The market was being combed for planes of almost any type, obsolescent or not, which might be pressed into service in the emergency, the imminence of which increased with every day's march of the Germans through the Low Countries and France. These obsolete Army attack planes, now designated as light bombardment, served to maintain a reserve in the threatened invasion of Great Britain. (NOTE—A British policy which we might well study to our advantage, is that of maintaining a heavy depot reserve of all types, so that the replacement factor is one which they can count on as being in their favor, and one which may in itself spell the difference between victory and defeat.) They have been used subsequently for general reconnaissance in quiet areas and for advanced flying training.

About this same time, the British also acquired a number of Grumman fighter planes, single-motored biplanes, and a quantity of Brewster single-motored low-wing monoplanes, which had been sold back to the manufacturer for that purpose. The Grummans were renamed the *Martlet* and are in use with the Fleet Air Arm, while the Brewster planes built for operations with Navy aircraft carriers, have been sent to Singapore, where they are now being employed as fighters by the Royal Air Force.

After the surrender of France, the British took over many of the French contracts in this country, one of which, was for

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several hundred Martin 167's a twin-motored bomber. Several minor changes had to be made on these planes. The throttle on French planes, for example, must be pulled back to increase speed, while on British and American planes it is pushed forward. With little difficulty it was revamped for use by British pilots and large numbers of them were sent to the Middle East for the campaigns in Egypt and North Africa. Many were sent also to the South African air force, and used both as bombers and as long range reconnaissance planes. A newer type Martin is now on order.

Another French contract taken over by Great Britain was with the Douglas Aircraft Company for a larger number of *Bostons*, a bi-motored mid-wing bomber designed as a fast day bomber. It was lightly armored and armed, relying for defense on speed. When the British *Blenheim* and Fairey *Battle* types and German Ju-88, all designed on this same principle, were shot down in large numbers, it was learned that speed alone was not enough protection for day bombing and that day bombing, in many cases, was too expensive in comparison with the results obtained. Because of their speed and exceptionally good flying characteristics the *Bostons* are now being equipped with additional machine guns and employed most successfully as night fighters. This is another type still being delivered.

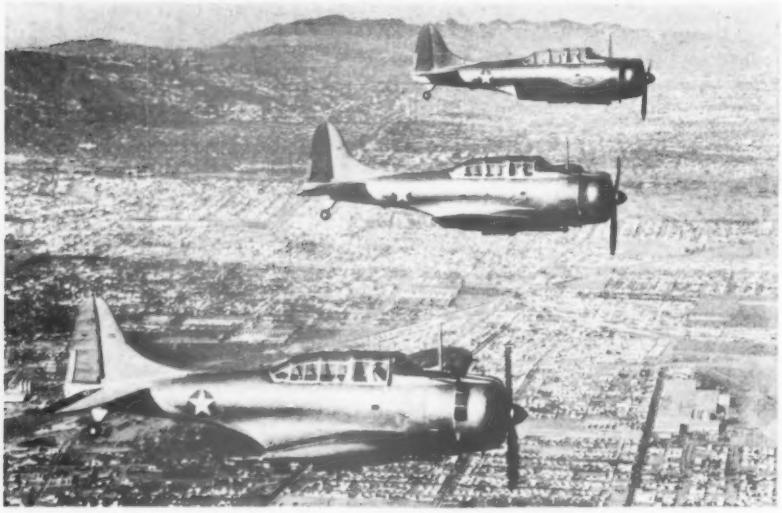
A large number of Curtiss fighters of the P-36 type were acquired from the French. Renamed the *Mohawk*, they are now in reserve for possibly emergency use in South Africa and the Middle East. While no more of this older type is being delivered, the new Curtiss P-40, called the *Tomahawk* by the British, has become the mainstay of the British air forces in the Near East. Since much has been said about this plane in comparison to other British types such as the *Spitfires* and *Hurricanes* and the German Me-109, some further discussion might be in order here.

The P-40 compared more than favorably in performance with the *Spitfires* and *Hurricane* first series and with the Messerschmitts. Some improvements have been made in later series of these types, but there is little to choose between them, and the P-40 still has not been exceeded in maneuverability and ease of handling. The British prefer mounting guns all of the same caliber, while we have followed the policy of using both .30 and .50 caliber. A reasonable number of P-40's or *Tomahawks*, were delivered in England and are still in reserve there, but one of the principal reasons for the major portion being sent to the Near East is one of supply. There is an enormous advantage in having planes of one type in one area, the problem of spare parts and maintenance simplifying themselves tremendously over those in sectors where many types are used. Therefore, since the production of *Spitfires* and *Hurricanes* had been increased to where there were sufficient to equip all the fighter units in the British Isles and to maintain an adequate reserve, the P-40's were not put in service but were retained as an additional emergency reserve.

A plane which the British have found most useful is the PBY, the bi-motored flying boat manufactured by Consolidated aircraft. The Navy turned a number of this type over to Great Britain's RAF Coastal Command. They are used in long range reconnaissance especially along the convoy route to the north and west of Scotland and Ireland and far out in the Atlantic on the watch for submarines and surface raiders. It was a plane of this type which spotted the *Bismarck* in her flight toward the French coast after sinking the *Hood*. The PBY's are flown over and more are being turned out as fast as facilities will permit.

Deliveries are steadily increasing on the B-24—called by the British the *Liberator*—a Consolidated four-motored land plane type bomber. A few are being used to fly ferry pilots back to this country, but most of them are employed by the Coastal Command on long distance reconnaissance missions. They also are flown from the factory to England.

First Army dive bombers, these two-place, all-metal Douglas A-24's are nearly identical with Navy and Marine SBD-3's. They will out-perform famed Stukas.



B-17 Boeing four-motored bombers, the *Flying Fortress* type, already have been delivered to England and have participated in daylight bombing raids over Germany. They are especially suited to day bombing because of their high speed and exceptionally high ceiling. Many more of these are on order and will be coming off the assembly lines in the near future. In addition there is a large number of the newer American types on order, delivery of which will be starting sometime in the near future.

This steadily rising tide of aircraft deliveries has not been attained without some difficulties, of course, but even there the situation is improving. For each American type plane ordered, the British have designated a "foster" company in England, which takes each plane and installs such British equipment as is desired and makes such changes as may be necessary to accommodate this equipment or to satisfy ever changing special service requirements. For example, the British may desire to install their own type of radio equipment in the interest of standardization and because of a lack of familiarity with the American product and a lack of trained technical personnel for its proper maintenance. This substitution of radio equipment may necessitate minor changes in the airplane, which are now made in England by the "foster" company. Or the British may feel it necessary to install a British type of gun for the reason that plentiful supplies of British-made ammunition may be available while it may be difficult to obtain ammunition for the American guns or to arrange speedily for the manufacture of this ammunition in England. To change from an American to a British gun, however, may necessitate changes in the gun mount and ammunition-handling equipment. Or, in some cases, the British may desire to install special navigational equipment or instruments which they have on hand in England. This can best be done by specialization within the "foster" company, by which the delay in making necessary alterations to receive new equipment is cut to a minimum. As rapidly as possible, however, arrangements are being made to have changes necessitated by the lack in England of supplies or special technical personnel made in the factories in this country. Arrangements also are being made for the manufacture in this country of certain special types of British equipment to meet, again, the special requirements of supply and maintenance, so that it may be installed in this country during the process of manufacturing the airplane, thus eliminating a vitally important cause of delay.

Two separate depots have been established for the reception and maintenance of American planes and engines, where they can be completely overhauled by specially trained crews when necessary. In these and many other ways, some of which, it will be readily understood, may not be disclosed in detail, the American and British air forces are working together to make our Aid-to-Britain count to the utmost.

END

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As stated by Brig. Gen. Davenport Johnson, Assistant Chief of Air Corps. in Hearings on the Military Establishment Appropriation Bill for 1942, "The C.P.T. program is unquestionably assisting the Air Corps in the execution of its current expansion program".

Light planes are a vital factor in the success of this extensive pilot training program. In no other way are facilities available to train so many pilots so quickly. Germany *had* to use *gliders.* We have the advantage of *power* planes—low-cost *light* planes. We have the existing production capacity to quickly give training wings to more and more thousands of pilots—and *keep them flying* for the benefit of our National Defense.

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AIR FORCES PUBLICITY

The United States Army is one of the most public relations-minded organizations of its kind in the world.

By Lieut. Col.
ARTHUR I. ENNIS

Lieutenant Colonel Ennis was born June 27, 1894 in Illinois. He joined Aviation Section, Signal Corps in 1917. Command pilot and corps observer, he heads the Pictorial Branch, Information Division.

THE people of the United States have given more than a million of their sons and billions of their dollars to build an Army which they insist must be the best in the world. That Army belongs to the people of the United States and they have a deep and abiding interest in it. If the Army is to be a good Army, its morale must be high. And its morale will not be high unless there is good morale among civilians at home. Therefore, the people must understand the Army and must believe in it; nothing can undermine morale more quickly than the feeling among the people that they are being deceived, that they are not getting the real facts about their Army's progress.

That, briefly, is the reasoning which lay behind the announcement on Feb. 11, 1941, that the War Department was establishing a vast new organization—the Bureau of Public Relations. In the months which have followed, therefore, great care has been given to the creation within the flying service of an alert, intelligent organization to handle the relations between the Air Forces and the public.

The Air Forces Public Relations Section is part of the Intelligence Division of the Office Chief of the Air Corps, which is headed by Col. Robert C. Candee, veteran flyer and an expert on tactics. Through the Intelligence Division flows the latest information on military aviation, gathered by our observers abroad and from the reports of officers in charge of various Air Force projects here. Colonel Candee must make many delicate decisions as to how much of the information which his division gathers can be made public.

The Public Relations Section in the office of the chief of the Air Corps in Washington is the nerve center of an organization which reaches into every air station in the United States and its possessions. The Washington section consists of several units. Among them are News Collection, which gathers from newspapers and periodicals all items of interest to Air Forces officers and which prepares regular digests of this information for circulation among them; the Review Branch, which checks over material prepared about the Air Forces and which publishes the Air Corps News Letter, organizational periodical circulated throughout the Air Forces; the Press Relations Branch, which prepares releases for newspapers and handles inquiries from the the press; the Radio Branch, which arranges for radio time; and the Special Assignments Branch, which helps prepare material for speeches and similar extra activities.

From the Washington organization come particularly important announcements regarding Air Forces policy, new kinds of equipment, changes in command or organization and other matters which are of national interest.

In the field, a public relations officer and staff are maintained at the headquarters of each of the four Air Forces and the Combat Command. Every Air Forces field, every training center and every school, has its public relations officer. These officers handle inquiries from the local press and dealings with local radio stations and public groups. They act under well-defined instructions from Washington on the kind of information which they may release. Generally, their job is to keep the public in their section informed on matters of interest to the locality. Such matters might include the progress of a local boy who had been on duty with the Air Forces in another locality, the arrival in the locality of a new squadron of planes, or plans for expansion of the local flying field.

The general purpose of the Air Forces Public Relations Section is to release to the public all available information on air activities and at the same time to safeguard Air Forces secrets. The American press has, for several months, refrained from printing facts and figures about the Air Forces which might be of value to unfriendly powers—information about plane speeds and performance, about secret devices, production rates, etc., except where such information is officially released. The Washington section and the local public relations officers watch to see that unwitting violations of this understanding do not occur and keep the confidence of the press so that deliberate attempts are not made to violate it.

The public relations officers in the field are advised to be completely frank and honest in their dealings with the public and representatives of organizations through which news reaches the public. The Army knows that nothing breeds suspicion so quickly as attempts at evasiveness or "covering up". During the last war wild rumors circulated by the hundreds throughout the country—rumors which would have died quickly had there existed a better organization within the Army for disseminating the truth. This time, the Army has a weapon with which to fight such whispering campaigns. A story got under way recently that, at one center, 30 men had died from pneumonia and that the Army had clamped a censorship on

(*Continued on page* 206)

Col. R. C. Candee

Lt. Col. F. A. Allen

Lt. Col. F. V. FitzGerald

Lt. Col. R. B. Lord

Maj. F. M. S. Miller

Lieut. R. C. Kinkead

TEN MEN ON THE GROUND FOR ONE IN THE AIR

IN commercial aviation—and aside from the military—there are about ten men engaged in servicing and operations to every pilot flying aircraft. Twenty thousand people are at work on the ground to keep commercial transport planes in the air. Of United Air Lines' 3,400 personnel, for example, only 357 are members of actual flying crews.

Another trained army of technicians and workers is employed directly in aircraft production—more than 225,000 in March of this year. The figure increases daily. Additional thousands are engaged, moreover, in supplying materials, instruments and tools to the aircraft industry.

"Today more than ever," states President Wm. A. Patterson of United Air Lines, "the man who is trained for a ground job in aviation has a vital role not only in maintaining the existing standards of air transport, but also in making possible the great future development of aviation."

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Pilots and Aircrews

(*Continued from page 71*)

Today there is one to four. The ships are provided by the Army on a "loan" basis and are maintained by the school under contract terms. They are kept on the go eight hours a day, with each cadet getting two hours of flying daily. Airplane and engine maintenance is handled at night. There is one Army officer on duty to each 16 instructors, supervising all school activities and acting as check pilots for instructors as well as students. Army specifications are followed to the last detail, even to cadet diet and spare-time activities.

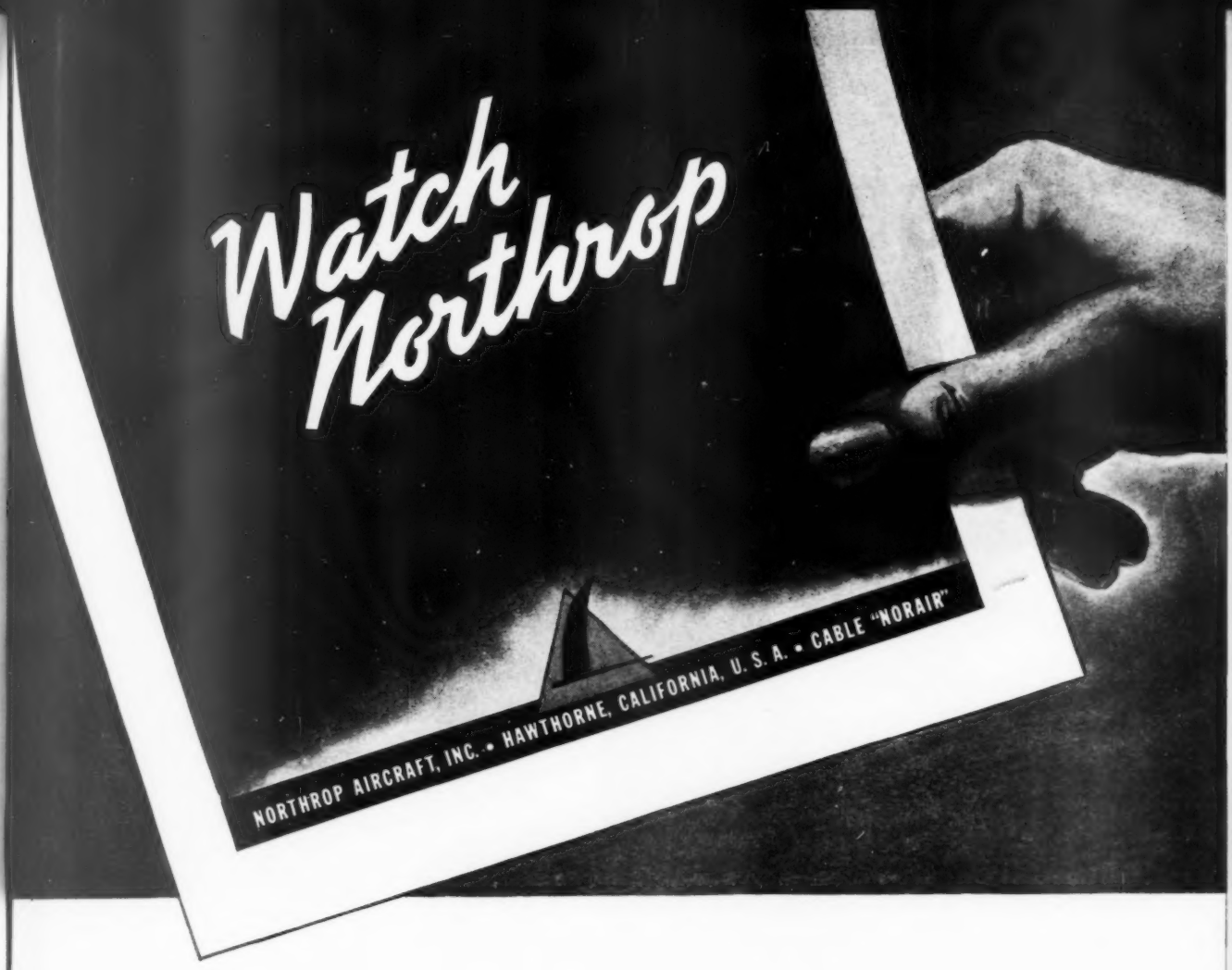
The primary stage of instruction covers

Wing insignia, top to bottom, of pilot, senior pilot, dirigible pilot, balloonist and observer. Wreath encircling senior pilot's star indicates a command pilot.

60 flying hours and 141 classroom instruction hours. About 57 per cent of the cadets enrolled in the 28 civil flying schools go on to the Army training fields to complete basic training; in other words, a little more than 30 per cent of the students are "washed out" during the primary training period. Lack of co-ordination accounts for 75 per cent of elimination.

Establishment of the civil contract school system has removed all primary flight training from Randolph Field, but, even so, it has been necessary to break up the burden of basic training. Five other Army fields now are carrying on basic training, or soon will be ready to. Basic training has been cut from 16 weeks to 10 weeks and average flying time from

(*Continued on page 144*)



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One year ago, we—with all of aviation—faced an impatient and not-too-well-informed America,—an America that little realized that the cement poured into foundation forms was as vitally important as the driving of a last rivet into a swift pursuit. We suggested "Watch Northrop" in the belief that the unfolding of the story and progress of this organization would assist, in at least a small measure, in bringing about a clearer understanding of the fact that aviation progress cannot be measured in plane production alone.

To date, Northrop production has been a comparatively small contribution to the Air Forces of the Democracies, but, Northrop progress may be credited as an almost impossible-to-duplicate asset. Today, a plant of half a million square feet houses one of the nation's most effective airplane engineering and manufacturing organizations. The plans are completed, the dies cast, the templates made, the jigs built, the men trained—and Northrop is moving forward quickly to add $45,000,000 worth of airplanes, within the next 18 months, to America's amazingly rapid rise of plane production.

This swift rise of Northrop is typical of the industry. In fact, "Watch Northrop" is the title of but one chapter in the great story of *Aviation-In-Action* in a democracy!

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LARGEST LINE OF RELAYS SERVING AMERICAN INDUSTRY

(*Continued from page* 140)

105 hours to 70 hours. These schedules are in effect at Randolph and the basic training fields—Maxwell, at Montgomery, Ala., and Moffett Field, Sunnyvale, Cal., and will be in effect at the new basic stations at San Angelo, Tex., and Taft and Bakersfield, Cal. Emphasis in training at basic schools is on technique and judgment. Washouts here average only about 14 per cent. During his basic stage, the cadet will put in about 262 hours in classroom study, 70 hrs. in drill and athletics and 70 hrs. in flying. While in primary, the cadet flew in a 200 h.p. primary trainer Now he graduates to a 450 h. p. basic trainer. It will take him about five hours to master the 60 or more controls and instruments crowded around him in the cockpit; his first 20 hours of flying will be about half dual and half solo. There is strong emphasis on precision flying and the cadet will go on to advanced maneuvers and finally night and instrument flying. The cadet who completes basic training is almost certain to earn his commission and wings—the average is about 99 per cent.

Completing the basic stage, he goes on to the advanced training stage and a plane with a 600-h.p. engine, retractable landing gear, more instruments and radio, including radio range beacon receiver. Here the emphasis will be on cross-country flying by day and night, instrument flying and orientation problems with radio directional aids, night navigation and increased formation flying. The working day includes about two hours flying and twice as much in the classroom.

The training trend is toward diversification. The Air Corps has begun to put into operation specialized flying schools for pursuit and bombardment crews. Pursuit training is given in the advanced flying schools at Selma, Ala., and Valparaiso, Fla. Another pursuit gunnery school is to be operated at Las Vegas, Nev., not far from Boulder Dam. Multi-engine training for combat crews, including bombardiers and navigators as well as pilots also is being given. Another innovation is the creation of schools for making specialists from Aviation Cadets failing to qualify as pilots. Formerly they were waste material so far as the service was concerned. These men now are given an opportunity to continue training with a view to becoming meteorological, engineering, navigation, communications, photographic and armament officers in tactical squadrons. They continue on flying cadet status and eventually receive Air Force Reserve commissions.

Squadron engineering officers are being trained at New York University and Purdue University, as described in another article in this issue. Armament and photographic schools are located at Lowry Field, Denver, Col. There is a communications school at Scott Field, Ill. Meteorologists are trained under contract by several universities.

The graduate Aviation Cadet, with his wings and commission, still faces three months' transitional training in combat command units before becoming a full-fledged combat squadron member. He gets about 60 hours' additional flying and more classroom work after arrival at the air base to which he is assigned. His flying begins in an advanced trainer for "check-out" purposes. Then he is ready for his first flying in a first-line combat airplane. For 20 hours he flies by himself to gain familiarity with the airplane and its instruments and accessories. He gets eight hours' gunnery practice, four hours' combat and aerobatic flying, six hours' night flying (including cross-country in formation), 12 hours' navigation practice and six hours' instrument flying. He then is ready for overnight cross-country flights, which may enable him to visit his home airport, if it is within reasonable distance; for firing on towed targets, for intensive formation work and for high-altitude flying, during which he becomes familiar with the use of oxygen. The specialized training in single- and multi-engine schools will eliminate much of this transitional training and will enable the newly commissioned officer-pilot to take his place more quickly in a fighting squadron.

Upon receiving his appointment as second lieutenant, the flying cadet's base pay is raised to $1,500 a year, plus $750 (half his base pay) for flight service. With rental and subsistence allowances, this gives him a total annual pay of $2,946. By the time he has been a first lieutenant for more than three years, but less than 10, he gets a total of $3,696 yearly. Should he advance to the rank of major, he will receive $5,436 annually after a total of 14 years in the service. As a major general his maximum pay would be $7,500 or about $650.00 per month.

(*Continued on page* 146)

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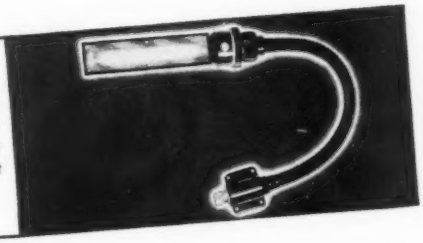
Electronic Ultra-Violet light gives *complete* instrument illumination . . . clear, sharply defined calibrations . . . eliminates objectionable glare from cockpit . . . guards against eye fatigue . . . *keeps pilot efficiency high!*

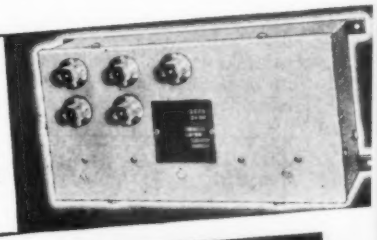
Army type numbers of Electronic Equipment illustrated on this page will be furnished upon request. Address the Lighting Division of Electronic Laboratories.

● *Electronic Type X-206 Lamp Assembly installed in cockpit of Bell Airacobra.*

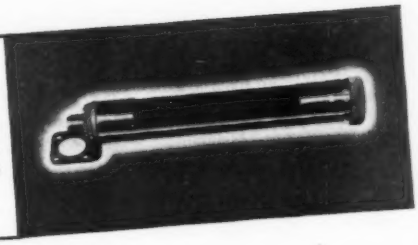
● **X-209**—Weighs 1 lb. 7 oz.; light filters through louver glass to produce soft glow. Designed for navigator or visible light in cockpit.



● **S-665**—Typical Electronic power supply; available to convert 12 or 24V DC to 110V AC and operate one to eight lamps. 400 cycle auxiliary boxes also available.

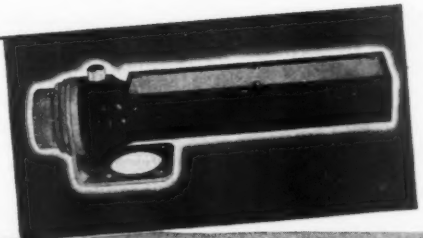


● **X-220**—Weighs 4½ oz. and is lightest of Electronic lamps. Produces ultra-violet with variable intensity. X-221 flexible arm model of same.

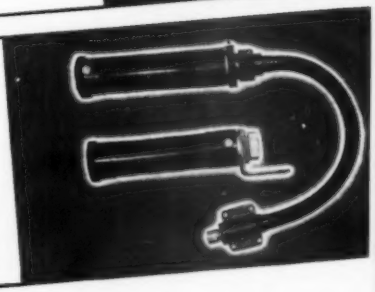


● **X-207**—Weighs 2 lb. 9 oz.; navigator's table lamp, available for operation on either 400 cycle AC or with inverters for DC.

● **X-208**—Weighs 8 oz. and designed for rigid installation. Otherwise similar to X-209.



● **X-206**—Weighs 1 lb. 9 oz.; offers either ultra-violet or visible light. Mounted on flexible gooseneck for maximum efficiency. Inset is X-205 which is same but for rigid mounting. Wgt. 12 oz.



ELECTRONIC LABORATORIES, INC.

LIGHTING DIVISION, INDIANAPOLIS, INDIANA

All these figures are for a single man on flying service, which means he must fly at least 100 hours annually.

The Air Corps is relying more heavily, as time goes by, on the CAA's Civil Pilot Training Program for its pilot material. At the time the 12,000-pilot program got under way, one out of five aviation cadets was a CPTP graduate and 4,813 CPTP students had enlisted in the Army or Navy for military aviation training. Studies at the Army's civil contract primary flying schools showed that although 39 per cent of aviation cadets without previous flight experience were being "washed out", only 17 per cent of the CPTP graduates failed to make the grade. The Air Corps at that time had taken 468 of the CPTP instructors for duty as Army flight instructors and 96 others for active duty with the Air Forces.

Air Forces leaders have stressed the high quality of the applicants for Air Forces pilot training and have said there is no intention of lowering the standards.

"The operations of the RAF in England have certainly shown that quality is of equal or greater importance than quantity in the personnel of an air force," Maj. Gen. Henry H. Arnold, Chief of the Air Forces, explained in a recent radio address. "One characteristic of a hazardous technical branch, such as aviation, is that the duties of every man, from command pilot down to apprentice mechanic, are vital to the safety and lives of individuals and the nation. A lowering of standards of efficiency is apt to be fatal. One of the heartening things about a democracy is that there are always men of character and capabilities who realize the blessings of liberty and are willing and eager to render the service required to preserve it."

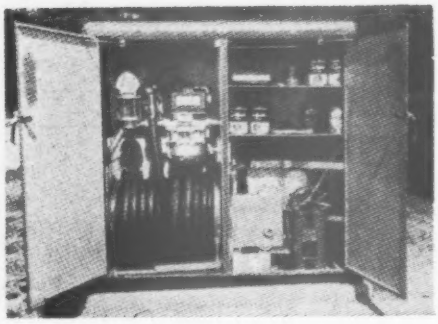
When the present emergency began, training of Army Air Forces pilots was concentrated at San Antonio, Tex., with primary training at Randolph Field and advanced at Kelly Field. Air Corps Training Center capacity was approximately 550 pilots a year. Since it became obvious very soon that facilities at San Antonio could not be expanded sufficiently to provide for the increased training required, the War Department adopted the present policy of utilizing civilian schools and carrying on Army training at other points than the Air Corps Training Center. This policy calls for Government payments to the schools. Regular Army instructors examine the graduates and give them their tests in Government airplanes to determine whether they meet military requirements. The Army also standardizes the instruction and the instructors, who themselves are trained to Army standards at the Air Corps Training Center to insure that they all are working toward the same goal. The Government lends Army equipment to the selected civilian contract schools.

There was an increase in Air Forces commissioned strength from 1,408 officers on June 30, 1937, to about 1,688 on Nov. 1, 1938, and estimates for the fiscal year 1940 provided for an average of 1,755, as a part of the regular program of annual increases. From this humble beginning, the present program for training 30,000 pilots a year has grown. At the time the emergency expansion began, replacements of Air Forces officer-pilots for all causes required about 2½ per cent of the total number annually. The 1940 budget provided for only 603 aviation cadets.

Even following the Munich pact, which set the world aflame and really marked the start of the American air defense program, growth of the Air Forces initially was slow. The average number of reserve officers on extended active duty in 1940 was 975, as compared with 857 in 1939 and the 1,350 authorized by the Act of June 16, 1936, for active duty with the Air Forces for not to exceed five years. The first plan for augmenting Air Forces strength after Munich called for a total of 4,663 officers—3,203 from the regular Army and 1,460 reserve officers on extended active duty. This required the addition to then existing totals of 1,565 regular officers and 603 reserve officers. This modest program, however, was outgrown very speedily and since then the goal has been raised many times.

Experience prior to the emergency had revealed that there must be approximately two training airplanes for every three operating combat airplanes. Experience, reinforced by events in Europe, indicated also that there should be at the outbreak of war enough trained pilots to man every combat airplane and to provide two crews for some combat equipment—certainly for bombardment and

A COMPLETE LINE FOR DEFENSE



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Illustrations: Vultee BT-13's at Air Corps West Coast Training Center, Moffett Field, Calif.

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reconnaissance, probably for observation and possibly for pursuit. This was the minimum. The modern airplane can remain in continuous action longer than its crew and, with duplicate crews available, can be kept in operation almost continuously for considerable periods in case of serious emergency.

The 27 existing civilian primary training schools now holding Air Corps contracts are the Alabama Institute of Aeronautics, Tuscaloosa, Ala.; Allan Hancock College of Aeronautics, Santa Maria, Cal.; Cal-Aero Training Corporation, Glendale, Cal.; Cal-Aero Training Corporation, Ontario, Cal.; Cal-Aero Training Corporation, Oxnard, Cal.; Dallas Air College, Dallas, Tex. Darr Aero Tech, Albany, Ga.; Lincoln Flying School, Lakeland, Fla.; Mississippi Institute of Aeronautics, Jackson, Miss.; Missouri Institute of Aeronautics, Sikeston, Mo.; Parks Air College, East St. Louis, Ill.; Ryan School of Aeronautics, Hemet, Cal.; Ryan School of Aeronautics, San Diego, Cal.; Sparton School of Aeronautics, Muskogee, Okla.; Sparton School of Aeronautics, Tulsa, Okla.; Texas Aviation School, Ft. Worth, Tex.; and the following 11 new schools which were awarded contracts in January, 1941: Air Activities of Texas, Inc., Corsicana, Tex.; Brayton Flying Service, Inc., Cuero, Tex.; Emery-Riddle Co., Arcadia, Fla.; Graham Aviation Co., Americus, Ga.; Lou Foote Flying Service, Stamford, Tex.; Oklahoma Air College, Inc., Oklahoma City, Okla.; Palo Alto Airport, Inc., King City, Cal.; Pine Bluff School of Aviation, Pine Bluff, Ark.; Rankin Aeronautics Academy, Inc., Tulare, Cal.; Southern Aviation School, Camden, S.C., and Southwest Airways, Inc., Phoenix, Ariz.

First classes entered each of the 1941 schools on Mar. 22, 1941, with new classes scheduled to enter every five weeks thereafter. Approximately 100 aviation cadets are to be in training in each school. The growth in the size of classes enrolled in the civilian training schools is as follows:

May 18, 1940, 475; June 29, 1940, 599; Aug. 3, 1940, 899; Sept. 14, 1940, 1,121; Oct. 19, 1940, 1,327; Nov. 30, 1940, 1,430; Jan. 4, 1941, 1,688; Feb. 15, 1941, 1,688; Mar. 22, 1941, 2,383.

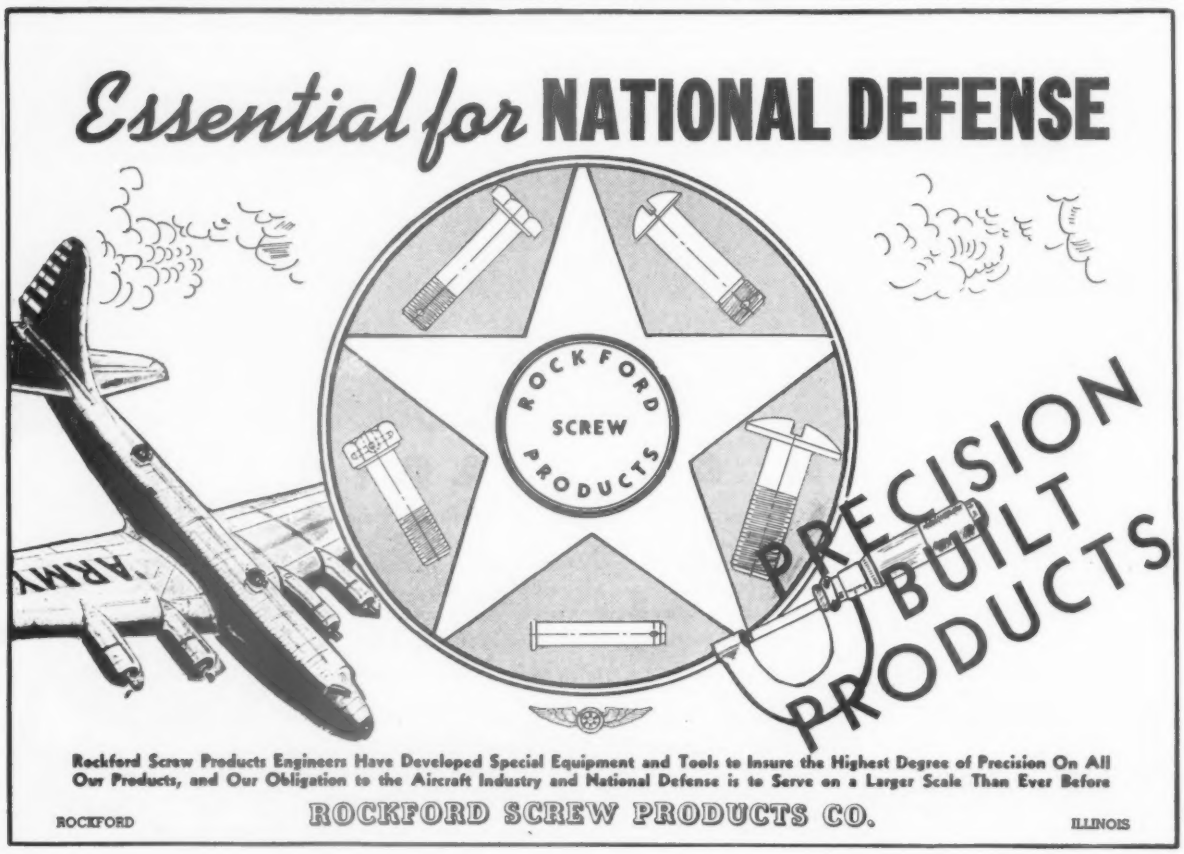
Plans for future classes contemplate student enrollments in groups corresponding to the size of the class of March 22, 1941, according to latest War Department plans.

All elementary flight training is conducted at the civilian contract schools. Basic and advanced training is given at the three Air Corps Training Centers: the Gulf Coast Training Center, the Southeast Training Center and the West Coast Training Center. The Gulf Coast Center took over the former Air Corps Center at Randolph Field. The West Coast Center, consisting of an Air Corps Training Center headquarters and such basic, advanced and specialized flying schools and other schools as have already been created or may be established, has established headquarters at Moffett Field, Cal. The Southeast Center has headquarters at Maxwell Field, Montgomery, Ala.

During the summer of 1940, the War Department entered into an agreement with Pan American Airways covering training of 850 flight-navigation cadets in long-range navigation technique during a period of 14 months, to terminate in the winter of 1941-42. The first class of 50 cadets began work at Miami, Fla., Aug. 10, 1940, and subsequent classes were enrolled at six-week intervals, the first three of about 50 each and later classes of 100 each, the last class to start Oct. 4, 1941. The course's duration is 12 weeks.

The cadets are housed in quarters made available by the University of Miami, which also provides classrooms. Army Air Corps officers who supervise the cadets are housed with them. Pan American Airways provides the instruction and all necessary flight-training facilities on a non-profit contract basis. It is using some of its most experienced personnel as instructors. Students for the flight navigation course are selected in much the same manner as those chosen for flight training. Flight navigation cadets completing the training are available for assignment to combat squadrons as crew members in *Flying Fortress* and other long-range and medium-range bombers.

An advanced flying school for training aerial observers has been established at Brooks Field, Tex., and the course is open to junior officers of company grade of all arms and services. The initial class for the 10-week course was enrolled Mar. 22, 1941. A class will enter training every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five weeks. Courses of instruction include ground school, day and night navigation; day, night and photographic reconnaissance; artillery adjustment of fire, and infantry and cavalry missions. Upon graduation, officers are rated as aerial observers and returned to their ground units, to be available for assignment to an observation squadron upon recommendation of their Army commander.

Other schools are training non-flying Air Corps officers who, on completing nine months' training, are available as engineering, armament, communications and photographic officers. The engineering trainees are selected from the ranks of former aviation cadets and qualified civilians, at a rate of about 100 every three months. They are sent, in approximately equal numbers, to New York University and Purdue University for intensive 12-week courses, after which they are assigned for six months' additional ground work at Chanute Field, Rantoul, Ill.

Armament and photographic officers are instructed at Lowry Field, Denver, Colo., while communications trainees are assigned to the Scott Field school, Belleville, Ill.

Many other specialized Air Corps schools are playing roles in the national defense program. The opening of a school for instructing of Air Forces officers in new techniques on high-altitude flight, with emphasis on oxygen equipment use, was announced Jan. 15, 1941, by the Air Corps Materiel Division, Wright Field, O. The initial course, at the Wright Field Aero Medical Research Laboratory, began with 30 officers from Air Corps tactical and training centers. This is but an example of the specialized training in progress.

And behind all this training activity is one fundamental purpose: the creation of air power sufficient to guarantee American security.

END

Photography

(*Continued from page* 108)

Field allows a "blitz" technique, providing complete pictures of enemy activities immediately fronting a position. Focal point is a portable field darkroom set developed by the author. Designed primarily to provide a front line laboratory which can move readily with division headquarters, this portable lab can be used to develop and print aerial photographs on the ground or in the cabin of the larger military airplanes. It weighs approximately 50 pounds and can be set up in less than five minutes.

A camouflaged tent, five feet square, it is supported by four pneumatic arches which can be inflated with a hand pump, air flask, or from the spare tire of a "blitz buggy." An inner lining of black fabric makes it light-proof. A rubberized fabric, water- and acid-proof, covers the ground to provide a floor. Separate zippers on lining and tent constitute the door. A light, compact air-conditioning unit furnishes hot or cold filtered air under temperature control for tropic or arctic areas. Water is carried in a rubber reservoir. Single prints on waterproof paper are turned out within five minutes after they are dropped from the photographic airplane, prints from cut film likewise come out in five minutes and from roll film in 25 minutes. Three darkrooms used together can develop 75 feet of nine-inch film and begin delivering prints within an hour.

In World War I, photographic laboratories commonly were placed 30 miles behind the lines. Hours would pass before negatives could be flown back to this point and prints delivered over 30 miles of muddy roads to the division commander. By the time photos were distributed to battery commanders, the pictured target could well have moved to an unknown position.

Today's portable laboratories are employed practically only for rapid production of short-range intelligence pictures. They are not intended for processing large scale battle maps or long-range aerial reconnaissance photographs. These are handled in base laboratories farther behind the lines.

Today, cameras record dial readings during test flights, leaving the pilot free to operate the plane. In addition to remaining conscious throughout every second of the most extreme power dives and outside loops, the camera can tell just what each instrument dial indicates at any given second. Christened the "photo observer" by the Air Forces men who de-

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signed and developed it, the device enables the pilot to record instantaneously readings from at least seven instruments on smaller planes. On larger ships, with room for installation of many more instruments, simultaneous split-second recordings can be made of as many as 15 dials.

Essentially, the photo observer is a 35 mm. motion picture camera with a light-box for uniform illumination and a panel mounting instruments whose recordings are vitally important in calculating test flight results. (The 35 mm. equipment is giving way to 16 mm. cameras, which are less expensive to maintain and operate.) Instruments on the panel duplicate those on the pilot's instrument board and also may include special gauges and meters for additional test information. The present version of the photo observer weighs only 35 lbs. It includes a movie camera with wide-angle lens, attached to the housing by a bracket so that the lens is 12 inches from the instrument panel. This compact unit, easily altered for each particular test, is entirely separate from the pilot's instruments. Light is provided by six 32-candlepower auto headlight bulbs (eight in the larger housings). Arranged on a rectangular frame inside the housing, they are outside the photographed area's field, thus eliminating reflection. The instrument panel itself has a black wrinkle finish designed to minimize light reflection. A small identification card is mounted on the panel, so that each movie frame records the test date, the ship tested, the pilot's name and other important information.

The camera can be detached for removing exposed film and reloading without disturbing the rest of the setup. It is operated by a 12-volt electric motor controlled by a trigger on the pilot's stick. The lamps are on the same circuit, so that they are lighted the instant the camera begins to operate.

The new device is especially valuable in such work as take-off tests. During a take-off instrument readings change rapidly. The camera is operated continuously, obtaining far more complete data than the most agile pilot could hope to jot down.

Another important test is the "sawtooth" climb, in which the pilot flies at specified speeds for definite intervals at various altitudes, to determine the plane's rate of climb at certain heights and to ascertain its maximum climb performance. During this maneuver the pilot merely presses the camera trigger and exposes film for from three to five seconds at each 1,000 foot level, thus making a complete record of the ship's performance at various heights during the test. To facilitate the exposure of these picture strips at the proper intervals, an "intervalometer" has been developed which operates the recording camera automatically. This method has been found extremely valuable in testing large planes such as the Boeing XB-15 and the *Flying Fortress*.

Virtually all apparatus in the photo observer is obtainable as commercial equipment and is being used by many commercial aircraft companies. The result is that better airplanes are being built and tested at an increased rate.

The Wright Field test experts also check landing and take-off characteristics with the movie camera. A performance-recording camera, like those for checking accuracy in aerial gunnery, is used. It takes standard 35 mm. film. Marker flags numbered from one to 30 are placed in numerical order at intervals of 100 feet on a 3,000-ft. course. A portable camera shack is located on the perpendicular bisector of the course, 1,500 feet distant. One shot is snapped to record the time and the airplane's position with relation to the marker flags. Continuous shots are filmed from a point preceding the take-off until the plane has reached an altitude of over 50 feet. In landings, the camera picks up the plane at an altitude of approximately 50 feet and follows it until the wheels stop turning. From start to finish of each of these take-off and landing sequences, the stop-watch automatically makes a time record of the flight on the film.

After the film has been developed it is wound on a spool and projected vertically on chart cards. The film is turned manually, a frame at a time as desired. Essentially, the 3,000-foot course is reduced to a scale drawing onto which images of airplane, marker flags and stop-watch are projected in such a way as to make automatic correction for the fixed location of the camera and the plane's line of flight. The important advance contained in this method is that the charts show directly and without any calculations the actual horizontal and vertical distances of the airplane from each marker flag, with the time recorded on the film. All performance figures are reduced to conditions of standard sea level altitude in still air. This plan has proven very helpful in correcting landing and take-off characteristics of various ships tested.

More recently, Army experts have been experimenting with color film in still and motion pictures for research work at the Matériel Division. One day they rolled out onto a cement hangar strip the wingless fuselage of a new pursuit plane, started the motor and let the plane smash into a solid brick wall. After the impact they saw flames spurt from the metal wreckage. But the human eye was unable to determine at just which spot in the fuselage the fire first started to burn.

On the sidelines photographers were shooting the whole costly experiment in color movies. On the screen, the movies showed a thin streak of red appearing on the metal fuselage at the hottest point, indicating where the fire actually started. It was just in back of the engine, near the ignition switch. After locating this "hot spot" the engineers learned that a short circuit in the ignition wires had caused the ship to explode. They changed the ignition-box coils to remedy the weakness.

Color film also is employed to determine the thickness of oils after they've been used in engines at high speeds, to record the breaking up of gasoline molecules at high altitudes and to check other chemical reactions of lubricants and fuels.

For night photography the Army uses a flash bomb resembling a small demolition bomb of the type carried by attack bombers. It bursts in mid-air by means of an intricate timing device.

Various-sized bombs are used, weighing anywhere from seven to 100 pounds, depending on the altitude at which they are timed to explode. The higher the plane flies, the heavier the bomb, since a

(Continued on page 156)

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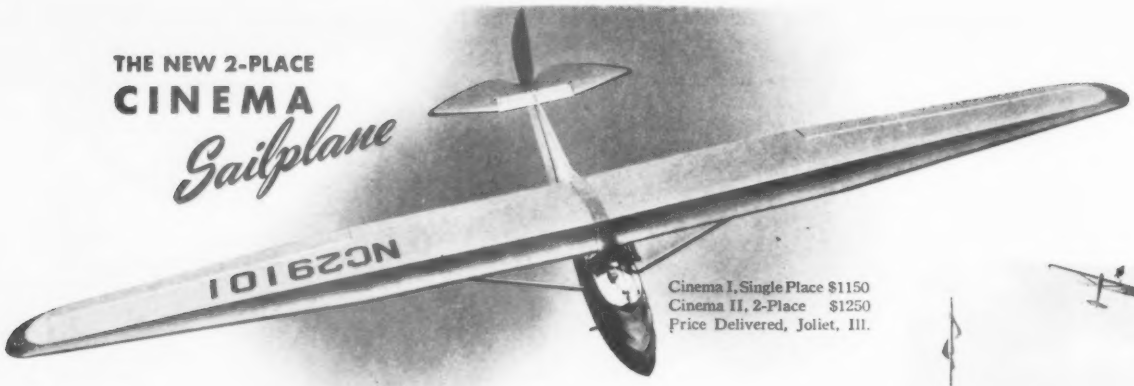

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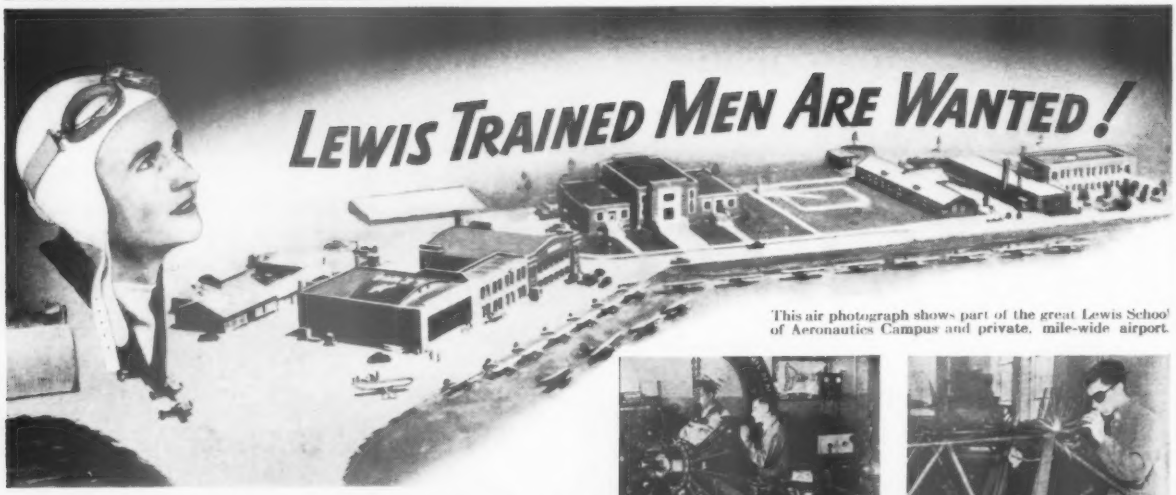
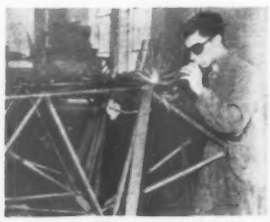


This air photograph shows part of the great Lewis School of Aeronautics Campus and private, mile-wide airport.

View of Engine Shop



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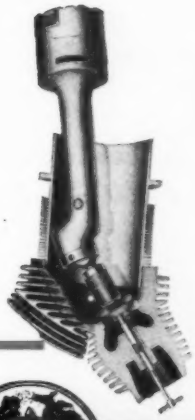

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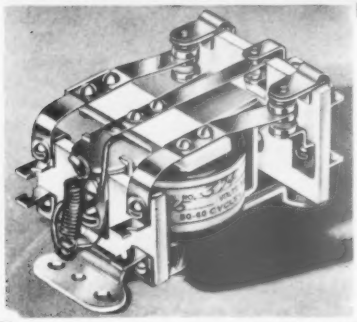

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(*Continued from page* 152)

larger area must be illuminated, necessitating more flash-powder content. Soon greater weights are to be tried. For peacetime tests the bombs are of lightweight materials which disintegrate harmlessly in the air. For actual warfare they also scatter shrapnel on the enemy.

Instead of being filled with TNT, the flash bomb is loaded with an intensive charge of light-producing flash powder made from special formulas. The powder is as highly explosive and just as dangerous to work with as TNT or nitroglycerin.

Reconnaissance planes now can accomplish more under cover of darkness than on daylight missions. In daytime they must fly at high altitudes, out of range of antiaircraft fire. This makes it difficult to get clear, large-scale, detailed photographs of enemy ground movements. At night the planes can remain at altitudes between 4,000 and 5,000 feet, which are the most desirable for night photographic operations, and at the same time be in less danger. At these altitudes the ships are too high for machine-gun fire from the ground and too low for accurate timing of the antiaircraft shells. Most pictures taken at night have been made from 5,000 feet, although the author has made successful photographs from as high as 12,000 feet.

Soon natural-color photographs will be possible from almost any height. Highly successful color pictures already have been made. The color camera is more accurate than is the human eye. At low altitudes objects on the ground can be seen in their true colors, but in higher regions colors start to fade. Haze in the air obscures the earth more and more as the altitude is increased. From heights above 12,000 feet the ground resembles a blueprint.

Studying closely the transparencies of a color photograph, generals can see where foliage has been used to hide a gun emplacement and the location of airplanes, trucks, tents, supplies, troops and equipment. Color film brings out the slightest changes in shading which occur a few hours after foliage is cut, making it comparatively easy to detect camouflage. Trees whose leaves have been scorched by powder blasts of a concealed gun are outstandingly apparent in a color photo. Likewise, painted backgrounds, which look normal to the eye at a distance, are obviously artificial in a color picture.

One stunt to counteract this technique is to hide an object by making it appear to be something else. The British are relying on this method. Antiaircraft guns have been concealed from aerial observers by erecting over each gun what appears to be a typical countryside cottage, complete even to the washing hung on an adjacent clothesline. The gun barrel is projected up the chimney and the "Hollywood set" house can be collapsed in a few seconds when the gun is ready to fire. Dummy planes built of wood, and fake airdromes, complete in almost every detail, also are being used to puzzle Nazi observers.

There is another problem; that of hid-

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ing aircraft from ground gunners, since antiaircraft fire is more accurate than it was in the first World War. Flat shades of green with light blue undersurfaces seem to be most desirable for daylight operations. Lampblack is used on the undersurfaces of bombers' wings and fuselages on night raids. Searchlights have been known to sweep across an airplane so camouflaged without detecting it. Exhaust stacks are mounted above the bomber's wings instead of below to conceal exhaust flames from the ground.

END

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Power Plants

(*Continued from page 116*)

Shortly after the war, a radial engine appeared commercially. Charles A. Lindbergh's colorful New York-to-Paris flight in 1927 was the radial engine's first international test. The Wright *Whirlwind* became as famous as the wartime Liberty.

Lindbergh's flight paved the way for aviation's commercial acceptance, which, in turn, demanded more and bigger engines. Manufacturers pioneered new foundry methods, new lubrication systems, reduction gearing, carburetion and cooling systems. They designed new machine tools to build them faster. Fuels were developed correspondingly fast, under the same stimulus. Anti-knock fuel was designed for airplanes; so was high-grade oil.

Attention on radial engines was centered in the U. S. largely because its manufacturers could keep abreast of military and commercial demands. The liquid-cooled engine has recently made a comeback after the War Department sponsored a practical 1,000 h.p. design competition. Main advantage of the liquid-cooled engine is the reduction of frontal area and consequent gain in streamlining efficiency. The success of the liquid-cooled engine brought about an answering achievement from the makers of radial engines, who now provide power plants with diameters not greatly in excess of liquid-cooled engines, but with far greater production facilities.

Wright Field's power plant laboratory is charged with developing new engines with increased power per pound of weight and standard dependability, durability and economy. The laboratory has another function—that of research into the pure science of airplane propulsion; development of entirely new designs; and creation of apparatus to test equipment which has not yet been built.

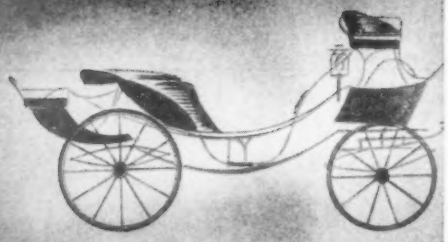
Some of the laboratory's subordinate units are: carburetor, fuel-injection, fuels and oils, installations (air-pressure pumps, accessory gear drives, engine and electric motor-drive pumps, propeller ice elimination, fluid metering pumps, cabin superchargers), controls, exhausts, silencers, cowling, and another accessories unit which tests fuel primers, bilge pumps, viscosity valves, thermostatic valves, intercoolers and similar devices. There are special units dealing with superchargers and ignition systems, special research, evaluations, maintenance and overhaul.

A typical engine under test at Wright Field would follow this procedure:

First, a short run on a test stand for a thorough operations check. Next, a dynamometer test where its actual power output is calibrated while other instruments reveal its fuel and oil consumption, cooling and other facts.

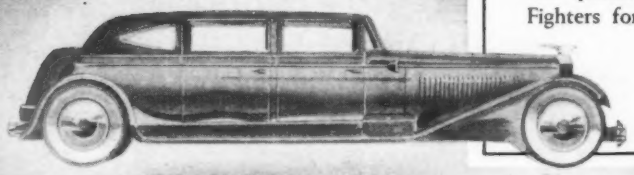
Then a test on the torque stand, where it is fitted with the proper propeller. Thereafter, the selected propeller becomes its teammate throughout its service life. Together, the team undergoes a 150-hour endurance run at speeds from idling to r.p.m.'s well above its rated

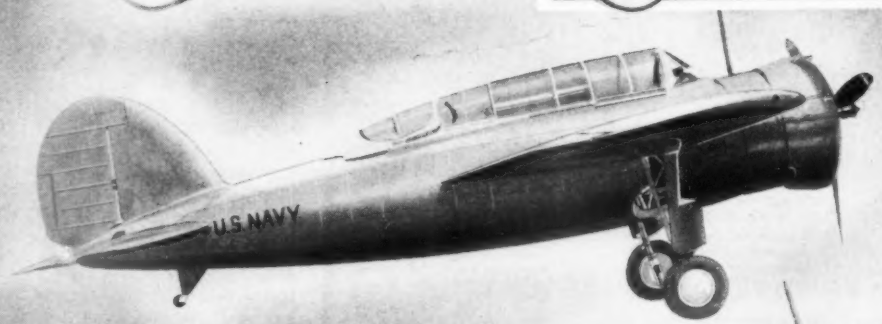
★ PIONEER ★

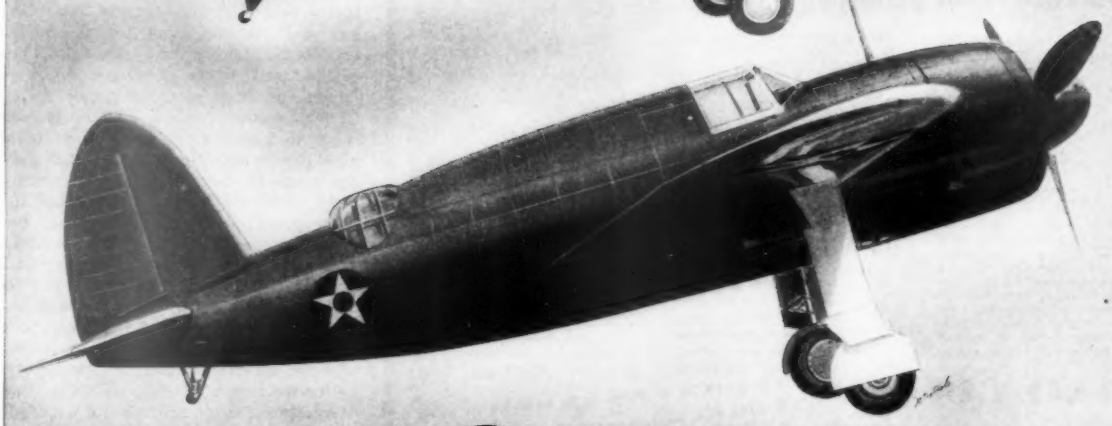


PIONEERING three important phases of transportation, Brewster set standards of quality in carriages as early as 1810, then in custom automobile bodies, and finally in the design and production of aircraft.

A new Brewster, latest development of the Dive Bomber type pioneered by Brewster in 1935, will soon supplement the quantity production of Brewster Fighters for the United States Navy and the Royal Air Forces of Great Britain and the Netherlands East Indies.







Brewster

FIGHTERS AND DIVE BOMBERS

FOR LASTING MASTERY OF THE AIR

power. Experience has shown that this test will reveal any major defects in either engine or propeller.

If the engine survives this ordeal it is given a series of acceleration and deceleration tests to reproduce power dive effects and other operating conditions. Then it is disassembled and inspected. All steel parts are examined by Magnaflux X-ray to determine hidden cracks.

Today, the national emergency has forced Wright Field to speed up these acceptance tests of new engine types. Standard practice previously was to place small "service test" orders with manufacturers, putting the engines into limited squadron service so that field work would build up a background of experience with them. Now these new types go to Patterson Field, where they receive "accelerated" service tests: continuous operation for days—or even weeks—at a time, with pilots flying in relays, as described elsewhere in this issue.

Joining engine and propeller in the power plant laboratory's work are self-sealing fuel tanks. Armoring, self-sealing devices and materials, tests of fuel for contamination with rubber lining, and repeated perforation of tanks by bursts of machine gun fire, are some of the section's responsibilities. Fifty-caliber bullets are shot through the tanks, ripping great holes. Linings must swell instantly and seal the holes, but not disintegrate and contaminate the fuel. All must work at sub-zero temperatures and at high altitudes. There has been more improvement in self-sealing tanks during the past year than in the preceding 20 years, but Wright Field engineers are not satisfied. They are planning now on defense of tanks against larger projectiles, perhaps aircraft cannon.

"Sloshing" tests show whether the tank is built to stand military service stresses. There is also an aging test and a gunfire test while the tank is chilled to below-zero temperature.

In the Wright Field fuel test laboratory are engineers who have strange little one-cylinder engines specially built to knock and ping like xylophones when running on various test fuels. They demonstrate different fuels' knock qualities. From certain previously-tested fuels a standard measurement has been developed, so that any fuel can be tested quickly for anti-knock qualities. Lately a super-fuel has been brought in for test which is even higher in anti-knock value than pure iso-octane. A new "yardstick" is being worked out for it.

Iso-octane has very high anti-knock quality. At the opposite end of the "yardstick" is heptane, which produces loud banging. All kinds of fuels are being tested every day. Part of the fuel-testing section's work is that of checking samples of aviation fuel bought by the Army. The Air Forces is one of the largest individual consumers of U. S. gasoline and lubricating oil. Samples of each purchase are tested. Latest figures show that the fiscal year ending June, 1939 (last year reported), showed an item of $6,423,615.18 for aviation gas and oil, representing 30,853,877 gallons of fuel and 709,260 gallons of oil. Some was lower-grade fuel and oil used in airport tractors and other machines. All was purchased under contracts prepared at Wright Field from specifications developed in the fuel test unit.

Finally, the most delicate part of the power plant team—the propeller—is subjected to exhaustive study in the propeller section. Those thin blades look fragile, but an airplane propeller's blades pull 40 to 60 times their own weight as they spiral through the air. The propeller section constantly seeks ways to improve the translation of engine power into the thrust which drives the plane in the air. Men and machines work in step with the power plant laboratory. From them came the four-bladed propeller for the 1,850 h.p. engines of the Martin B-26, first of its kind in the Air Forces and a forerunner of the six-, eight- and 10-bladed propeller which engineers consider the best answer to the giant engine. It allows a power increase without a corresponding increase in propeller diameter.

Another future goal is the dual-rotation propeller with multiple blades, some turning clockwise and others counter-clockwise. The effect is to neutralize torque; one set balances the torque created by the other. It is obtained by a system of gearing using two propeller shafts, one inside the other, in a way to employ each shaft to turn its proper propeller section. Dual rotation helps propeller efficiency at high altitude and high speed. Conventional propellers reach

(*Continued on page* 164)

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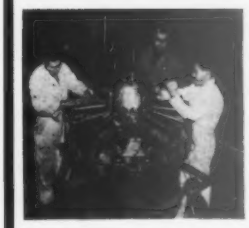

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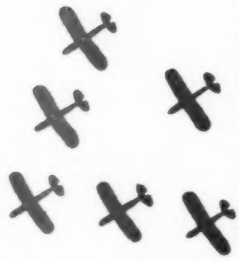

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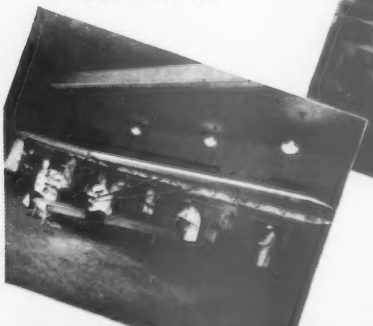

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(*Continued from page* 160)

peak efficiency at 350 m.p.h. The more speed above that point, the less efficiency. Blades must be turned to a high angle and much of the power is lost in the slipstream.

Dual-rotation blades will absorb part of this loss and maintain efficiency up to 450 m.p.h. The idea behind the device is not new. It appeared on the Wright brothers' first pusher, which had two opposite-turning propellers. A patent was granted in 1908 for a double-shaft drive similar to that being used now. In 1931 Harry Woods, at Ft. Worth, Tex., flew a plane with a similar device designed by M. M. Egan. In Italy, a world speed record of 440 m.p.h. was established in 1934 by a Macchi-Castoldi seaplane using a dual-rotation propeller. Its record was unsurpassed for four years.

Not until huge engines appeared did the dual-rotation design come into its own. Included in the newest system is another revision of an old idea—a gear-shifting system which slows down the propeller, yet gives the plane a higher speed. This dates from an experiment at the old McCook Field in 1924. Today's high speed airplane is in need of a geared propeller drive to meet varying flight conditions with a varying propeller speed while the engine is delivering full power.

One of the reasons why dual-rotation propellers and gearing systems are in demand now is because, with increasing acceleration, the propeller tip speed increases to such a velocity that it becomes a drag upon itself. A 1,000 foot-a-second tip speed is the practical limit. It is being exceeded many times by today's high speed engines and large-diameter propellers. That is why dual rotation and gearing systems, as well as new ways to change blade pitch, are increasingly important.

There are two kinds of controllable-pitch mechanisms, one electric and one hydraulic. Simplest is a two-position device which offers the pilot a choice between high and low pitch. In another model a governor varies the pitch angle automatically so that change of altitude results in a compensating change of pitch. This is the "constant speed" propeller type; the term refers to propeller speed, not engine speed.

A still more complex type can be turned to zero pitch, or "full feathering." In case an engine is damaged in flight, the usual propeller will continue to turn it over just the same, crushing bearings and grinding up broken parts. With a full-feathering device the propeller has no tendency to turn and will remain motionless, sparing the engine further damage and releasing the other engines in larger planes from the braking action of a windmilling propeller on a damaged engine.

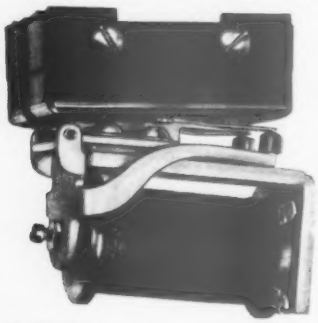
One of the most important research projects in the power plant laboratory is the de-icer section, wherein problems relating to ice conditions on wings, propellers and other parts of an airplane are being studied. Most effective device evolved thus far is a rubber cuff extending from the blade shank nearly half the length of the blade. In it are tiny tubes carrying a chemical solution which trickles out by centrifugal force to the blade's tip. The solution is a compound of alcohol and glycerine; in serious weather a propeller will use a gallon-and-a-half per flying hour.

In the laboratory's materials section, constant research is being conducted into stronger and lighter metals and their alloys. For engines of more than 200 h.p., Wright Field specifies all-metal propellers of dural, an aluminum alloy, or of hollow steel. Some wooden propellers, some solid steel and a few forged propellers are used on small training planes. In the testing section are rubber-steel, plastic, magnesium and plastic-wood combinations undergoing experiments for possible propeller use.

Giant whirl test rigs at Wright Field receive these experimental propellers. Electric motors turn them at speeds from 20 per cent to 100 per cent greater than those in flight. Thrust is measured on a hydraulic cell mounted in the shaft. Electric instruments, meanwhile, record the horsepower necessary to develop that thrust. These tests continue for approximately 20 hours, with the blades set at various angles. Engineers examine the test propellers constantly for signs of weakness, flutter, oscillation, or other bad habits.

If they survive the whirl tests, experimental propellers go to a torque stand,

(*Continued on page* 168)



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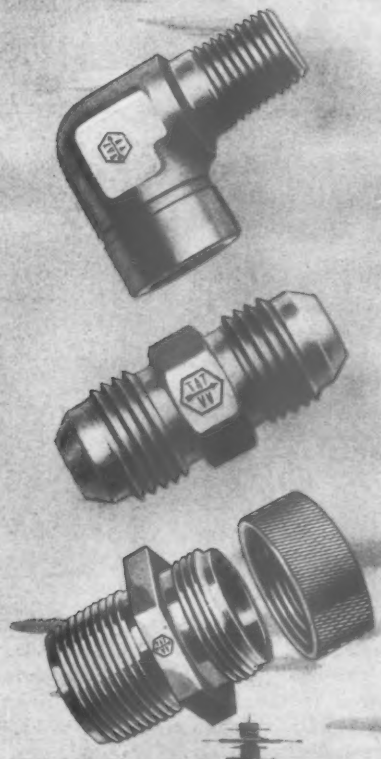

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SOUTHBRIDGE AO MASSACHUSETTS

(*Continued from page* 164)

where a 100-hour run at overload speeds is given them to measure torque developed. Another test is the "resonic frequencies" experiment, to see if vibration of engine and propeller together build up an exciting force which results in damage. Then come extended vibration tests which measure stresses in sample propellers both in flight and on test stands.

Controllable-pitch mechanisms receive 1,500 cycles of complete operation test under gruelling extra-load conditions to make sure they will function perfectly at all times. Propellers selected for certain engines are mounted on them and given more flight tests, with the plane being put through every conceivable maneuver.

Two hundred hours of service test in tactical planes complete the work out. Then, with proper recommendations, the new engine-propeller combination is turned over to the squadrons for service use.

The Wright Field propeller development experts are reasonably well satisfied with present controllable pitch devices. Research is continuing in an effort to obtain better and lighter installations. Since the load carried on a propeller blade may produce forces of 100,000 pounds, tending to pull the blade out of the hub, propellers must be balanced carefully.

END

Materiel Division

(*Continued from page* 83)

as a coolant in liquid-cooled engines made possible radiator size reduction by 60 per cent and gave the liquid-cooled engines a new lease on life. Innumerable new materials—nonshatterable glass which will not deteriorate in tropical climates is an example—have been developed.

Materiel Division test pilots—headed by Maj. Stanley M. Umstead, who recently flew the world's largest plane, the B-19, on its initial trip—put all new warplanes through their paces. And last but far from least, such famous types as the B-19, the *Flying Fortress*, the *Airacuda*, the Curtiss pursuits, and many others, first were conceived at Wright Field. Here, in the laboratory, engineers probe endlessly that American airmen, in war and peace, may keep ahead.

END

Parachutes

(*Continued from page* 115)

Each time the engineers thought they had developed the perfect parachute, they hauled out Dummy Joe, attached the new device to his well-stuffed form, took him up and heaved him overboard, twisting him into all sorts of positions to see what would happen to the 'chute, which rested on his back, his chest, or sometimes even the seat of his pants. The last idea was to prove best. When the parachutes failed, Joe suffered severe injuries, but they always stuffed him up again and he tried the whole procedure all over until the Army men thought they had the trouble fixed.

After many of these successes and failures had been tried Dummy Joe was discarded and Sgt. Ralph W. Bottriell made the first jump with a free type parachute on May 19, 1919. A year later he had more than 200 jumps from a moving airplane to his credit. A former cavalry officer, onetime balloonist and exhibition jumper, Sergeant Bottriell in 1932 was awarded the Distinguished Flying Cross for his efforts.

Congress was none too friendly to McCook Field's Parachute Branch. It was hard for the Air Corps to get funds to develop such an "impractical" device.

It took the parachute's saving of a life to convince the Government that money should be granted for further experimentation.

Before a life was saved, however, a man had to die. Lieut. F. W. Niedermeyer, one of McCook Field's most capable young flyers, had just returned from a test flight and had put his parachute away. Then, very much interested in a new airplane which had just landed

(*Continued on page* 172)

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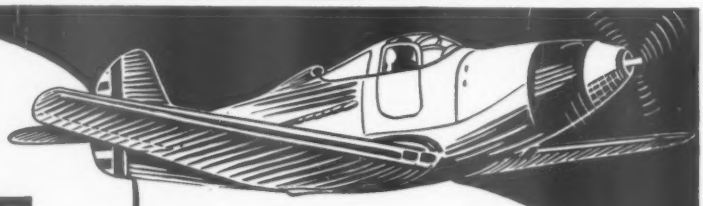

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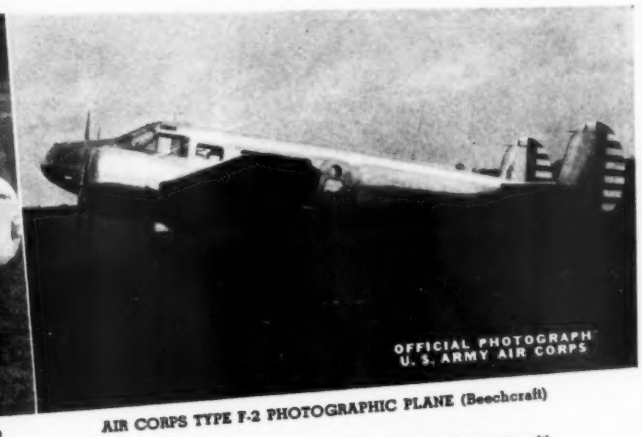

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(*Continued from page* 168)

at the field, he forgot to put on his parachute before he took the ship aloft. During a violent maneuver the wing tore loose and Niedermeyer plunged to his death. There was plenty of altitude and many believed that if the officer had worn his parachute he might have been saved. As a result of his death, McCook Field's commanding officer issued an order requiring the wearing of a parachute by every person in every plane. The order, a year later, was issued by the Chief of the Air Corps. It has been in effect ever since.

Lieutenant Niedermeyer died, but a fellow officer, Lieut. Harold R. Harris, lived—the first man to be saved by a free type 'chute in an emergency leap from an airplane. The incident occurred on Oct. 20, 1922. Then chief of the flying branch at McCook Field, Lieutenant Harris was testing a new type aileron. He put the plane into a quick bank. Immediately a vibration developed that couldn't be stopped. Lieutenant Harris climbed to the side of the plane and the windstream blew him off. He jerked what he thought was the release ring and nothing happened. He looked again, discovered he was pulling the leg strap. Finally he found the ring and jerked it hard. There was a snap; suddenly he was yanked upright and was floating earthward beneath a giant silk parasol. The airplane crashed, a complete wreck.

Within a month after Lieutenant Harris's escape, another McCook Field officer, Lieut. Frank B. Tyndall, was saved from death the same way. Today hundreds of Army men and civilians owe their lives to the parachute.

The first night parachute jump from an airplane was made by Lieut. John A. Macready. He "bailed out" when something went wrong with his craft while flying the new night test airway system between Dayton and Columbus, O. Because there was something "terrifying and spectacular" about leaping from an airplane at night, considerable publicity resulted.

Another interesting jump was that made by Col. A. W. Stevens from an altitude of 24,206 feet. The ship was a supercharged Martin bomber and Lieut. Leigh Wade was the pilot. A double training parachute was used. Strapped to one leg was a 70-cubic inch oxygen bottle. When Colonel Stevens left the plane he weighed about 250 pounds with all equipment. With him he carried a camera to record his descent. He was 20 minutes coming down. Although unofficial, a high altitude jumping record was established.

These experiences played an important part in parachute development. There have been many changes in design, many new trials, between these early attempts and present day equipment, however.

The free type parachute, as it was originally and as it is today, has changed little in principle. It is made of purest Japanese silk, nylon, rayon, or cotton. Because of the difficulty in procuring silk, the Army has been using substitutes, of which experts say there is an abundance. When the 'chute is open it forms a great white parasol about 24 feet in diameter. Closed, the aviator wears it folded in a small knapsack, attached to a harness which fits similarly to a vest. When flying, the pack forms a seat cushion.

To open the parachute, the jumper jerks a ring in a pocket in the left-hand side of the harness. The ring pulls a wire, which zips the knapsack open down the middle. Packed inside on top of the large parachute is a small, toy-size parachute with springs inside that cause it to shoot forth through the knapsack's zipper opening. The air fills the small 'chute, which pulls the large one from its container.

All of the many types of parachutes in use today work on this principle. Most common as standard equipment are the S-1 and S-2 types; these are Army designations, the "S" meaning seat type. They are used by Army flyers—pursuit pilots, for example—who do not move about in their aircraft, forming actual cushions for the pilots. The seats in the plane have no other cushions. The S-1 and S-2 types are 24 feet and 28 feet in diameter, respectively. They are made of silk, nylon, or rayon.

Another standard 'chute is the B-7 type ("B" for back type). This variety is used by flying personnel required to move about in the plane—gunners, bombardiers, mechanics, etc. The B-7 type is attached to the man's back in a streamlined casing that allows the wearer considerable freedom of movement. The pack is flat and the harness can be adjusted for comfort by the wearer, whereas with the other type 'chute the wearer must have someone else help him adjust the harness. Another development is an A-2 type 'chute. It can be stowed in the small turret space and attached quickly to the

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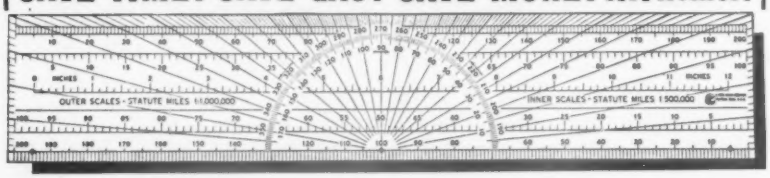

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harness the gunner wears at all times. A special snap arrangement designed by materiel division equipment engineers allows the gunner to attach the 'chute and get out of the turret. This harness has been outmoded by the improved, streamlined B-7 type.

Still another type 'chute is the standard training type, the T-3. This is a double 'chute with a back type 28 feet in diameter and a chest type 22 feet in diameter. It is used exclusively in teaching personnel to make emergency jumps and in 'chute operation instruction.

A special type training 'chute, the T-4, has been designed for training parachute troops. These 'chutes' dimensions are the same as regulation training parachutes. The difference is that the paratroop parachute is operated by a static line attached to the airplane. A special opening mechanism on the back pack enables the static line to pull open the pack and at the same time pull out the parachute. This is accomplished by using a 40-foot break cord which is broken by the jumper's weight.

The training and tactical types vary from 21 pounds to 30 pounds in weight. They cost anywhere from $150 to $200.

All these parachutes have been developed by the Air Corps Materiel Division, Equipment Branch, at Wright Field in Dayton, O. Here the experimental types have been designed and approved. Then specifications have been sent to five companies in the United States that make them for the Air Corps.

Recently, since the outbreak of the war in Europe and since the Germans have introduced the parachute troops so effectively the work at the materiel division has increased considerably, since now parachutes must be designed to support equipment as well as men. Also much new and before untried equipment has been designed to take care of the needs of the parachute troops.

To eliminate errors in judgment which could be fatal in low-altitude jumps, a 12-foot web strap attached to the parachute pack is snapped to the steel cable or static line. When the trooper bails out, this strap yanks the cover off the pack, automatically releasing the parachute. Straps and covers are blown out of the way by the air stream and are pulled back into the transport plane after all parachute troopers have bailed out.

The conventional parachute harness must be unfastened at three points. Because quick work is vital in getting into action once a paratrooper gets on the ground, Wright Field has developed a special quick-release harness. To operate it, the trooper twists a small disk, cocking a spring mechanism that releases the entire harness. On landing a brisk slap on the disk releases the fasteners and allows the trooper to wriggle free in one movement. Precautions have been taken so no waving of arms, etc., can release it in the air.

'Chutes designed for dropping specialized equipment for parachute troops are made of cotton. They vary from seven feet to 28 feet in diameter and are dyed various colors so that para-troops can

(*Continued on page* 178)

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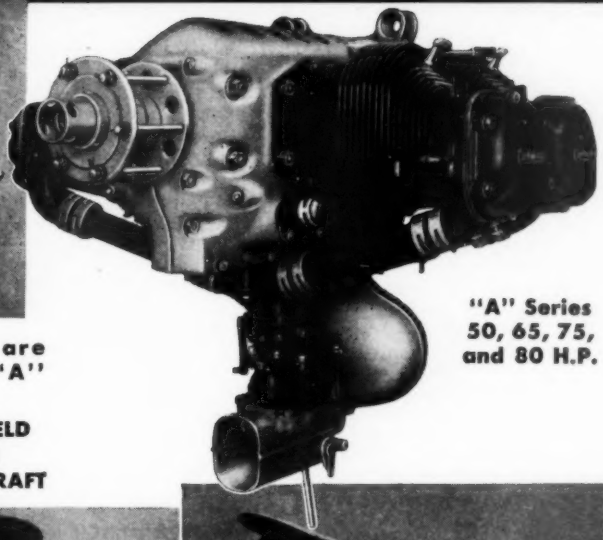

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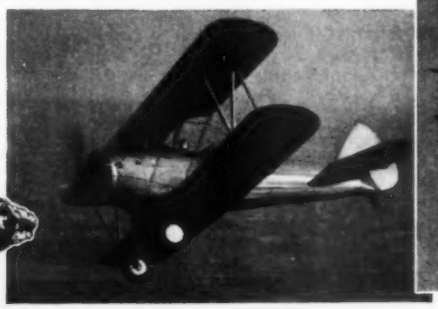

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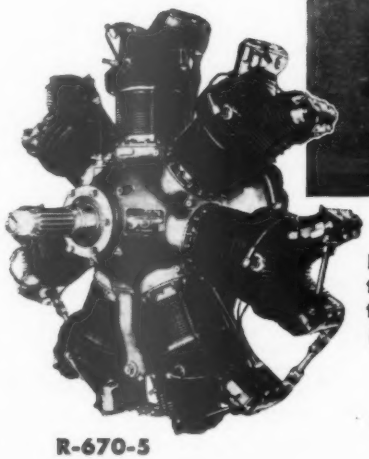

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(Continued from page 174)

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Maintenance Command

(Continued from page 123)

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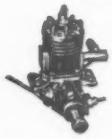

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Ground Crews

(Continued from page 74)

aviation cadets and civilians to qualify them as squadron engineering officers. It carries no pilot instruction and prepares graduates only for ground duty. The status, pay and allowances of cadets undergoing this specialized course is the same as that for cadets receiving pilot training. On satisfactorily completing the nine-month course they are eligible for second lieutenants' commissions in the Air Corps Reserve. Applicants must meet the general rules for appointment as aviation cadets, although physical requirements are less rigid than those required for pilot training. First priority candidates must be college graduates with a degree in engineering. Subjects include fundamentals of aerodynamics, airplane design, airplane engines and installation, airplane engines laboratory, airplane stress analysis, structure and aerodynamics of military airplanes, aircraft instruments, propeller design and aircraft detail design. Applicants receive 12 weeks at either New York University or Purdue University. Admission of 50 applicants to each university every three months beginning January, 1941, was planned. This is followed by six months' training at Chanute Field.

Schools for training squadron armament, communications and photographic officers also are being established. The armament and photographic schools have been located at Lowry Field and the communications school at Scott Field. A college degree, together with some training or experience in the subjects, are admission requirements. The courses each take about nine months; students have the same status as those in the engineering school.

The Air Corps found it necessary to double the capacity of its existing technical training facilities considerably early in 1941, and add new ones. The War Department announced Wichita Falls, Tex., and Biloxi, Miss., were to be sites of two new Air Corps Technical Schools costing $19,000,000. This raised the number of such Air Corps schools to five. At the same time, the number of civilian mechanics schools under contract was increased to 15. In April plans for increasing the number of Air Corps mechanics in training from 45,000 to 100,000 a year were revealed. About $5,000,000 will be spent for additional housing.

The Biloxi and Wichita Falls schools will enroll 80 enlisted students every 14 days for 22 weeks' aircraft mechanics instruction. Approximately 14,500 officers, enlisted men and enlisted students will be stationed at each institution. Each school is expected to turn out 20,000 aircraft mechanics a year. The program calls for erection of 16 barracks for each 1,000 men, in addition to administration, recreation, day and supply rooms.

The Air Corps Technical Schools and the civilian contract schools today are offering 19 courses for enlisted men:

Regular course: aircraft mechanic, aircraft armorer, aircraft machinist, aircraft metal worker, aircraft welder, supply and technical clerk, Link Trainer instructor, parachute rigger, photographer, radio operator and mechanic, teletype operator and weather observer.

Advanced course: bombsight and carburetor maintenance, electrical, instrument and propeller maintenance; advanced photography and weather forecasting.

Chanute Field's main function is training mechanics. From this school men graduate as mechanics, machinists, welders, metal workers, experts on carburetors, electrical systems, propellers and instruments. Link Trainer specialists and parachute riggers also are trained there.

Lowry Field specializes in armorers, clerks, photographers and bombsight maintenance men.

Scott Field's main products are radio operators and mechanics.

Chanute Field is general headquarters for the whole Air Corps technical training program. Here the courses for Army and civilian schools are prescribed.

Men selected for Air Corps Technical

(Continued on page 184)

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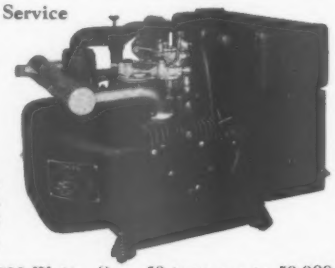

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(Continued from page 180)

Schools, Army or civilian, must be well grounded in elementary mathematics and must be recommended by their commanding officers. Applicants are tested for mental alertness and mathematical ability. When the candidate clears his preliminaries, he is placed on an eligibility list to await a vacancy. In a civilian mechanics' school, the successful candidate receives a special allowance for food and quarters. His military duties are reduced to a minimum. He faces a man-sized training program, however, and must keep plugging to make the grade. Eight hours a day, five days a week, he is in the classroom, laboratory or shop. During the evenings he studies and on week-ends he tours nearby factories. Sixty-five per cent of his time is spent on projects, the remainder in classrooms.

At the Air Forces operating airdromes the technical school graduate must spend many months working under sharp-eyed "old timers" before he can hope to qualify as an expert. School training, nevertheless, is the first major step in becoming a full-fledged Army aviation mechanic upon whose speed, skill and dependability rests the safety of the pilot.

Enlisted men's pay begins with $21 a month and private's rating. After four months this is increased to $30. As training and service lengthen, a man may rise to private first class ($36), corporal ($54), duty sergeant ($60), staff sergeant ($72), technical sergeant ($84), or master sergeant ($126). If he is on flight duty, he gets a 50 per cent bonus over his regular wages, while specialists' rating give him $3 extra per month as a sixth class specialist, $6 for fifth, $15 for fourth, $20 for third, $25 for second, or $30 for first. An air mechanic's rating (second class) pays $72 a month: first class, $84. This, however, is an air mechanic's total pay; he receives nothing extra for flight duty, non-commissioned officer's rating, etc. All ranks get more money with successive enlistments.

Pay of former flying cadets training to be bombardiers, engineering officers or for other technical posts is described in detail in the article on air crews elsewhere in this issue.

Air Forces growth and its effects on training and personnel standards has been described by Maj. Gen. Henry H. Arnold, Chief of Air Forces and Deputy Chief of Staff for Air, in a recent radio address.

"Two years ago," he said, "the Air Forces had 1,440 officers and 18,800 enlisted men; today it numbers 4,795 officers and 68,000 men and our future goal is 16,000 officers and 163,000 enlisted men, to be reached in 1942. Thus, you see, our future air force will be about nine times as large as it was a little over a year ago. This is based on present needs only. How large it will have to grow if we are forced to go to war is anybody's guess. . . .

"There is no adequate source of completely trained men. Even were the airlines and commercial aviation to be entirely discontinued, they would provide but a small fraction of the pilots and mechanics needed. And beside those there are a great many other specialists required, such as bombers, gunners, navigators, radio operators and technicians, weather forecasters, clerks, cooks and a hundred other kinds, many of whom have no civilian counterparts. Nearly all have to be trained in Air Forces methods regardless of how proficient they may have been in their civilian occupations. This is why it takes a long time to create an efficient air force and why the Air Forces at present are one big training school."

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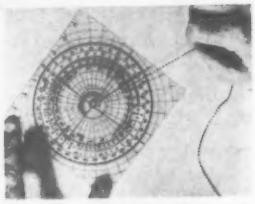

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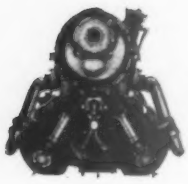

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Combat Command

(Continued from page 46)

Field, Spokane, the Army Air Base at Pendleton, Ore., and McChord Field, Wash.; the Twentieth Wing, medium and heavy bombardment, between fields at Salt Lake City, Utah, and Boise, Ida.; and the Eleventh Wing, interceptor pursuit, to bases at Portland, Ore., and Everett, Wash.

Headquarters of the Third Air Force is at Drew Field, Tampa, Fla. It consists of the Third Wing, medium and heavy bombardment, at Drew Field and McDill Field, Orlando, Fla.; the Twenty-First Wing, medium and heavy bombardment, at New Orleans, La., and Jackson, Miss.; the Seventeenth Wing, light bombardment, at Savannah and Ft. Benning, Ga.; the Eighth Wing, interceptor pursuit, at West Palm Beach and Tallahassee, Fla.; and the Twenty-Second Wing, interceptor pursuit, at Augusta, Ga., Charlotte, N. C., Baton Rouge, La., and Meridian, Miss.

The Fourth Air Force, with headquarters at March Field, consists of the Ninth Wing, fighter pursuit, at March Field; the Fifteenth Wing, light bombardment, at Fresno, Cal., and Oklahoma City, Okla.; the Tenth Wing, interceptor pursuit, at Hamilton Field, Cal.; and the First Wing, medium and heavy bombardment, at Tucson, Ariz., and Albuquerque, N. M.

In addition to these combat forces, each Air Force is assigned a transport group and also has reconnaissance squadrons. The latter are equipped with long-range planes for work beyond the immediate theater of operations and must be distinguished from the observation squadrons assigned to land forces for work entirely with ground troops. An important cog in the organization is the air base group, which comprises the facilities and installation required for the operation, maintenance and supply of a specific force.

The air base group usually includes a considerable area within its jurisdiction and all auxiliary airdromes come under its control. It prepares and maintains all the facilities at these auxiliary fields, so that the combat units may move in and begin operations without wasting time or effort on extraneous tasks. There are or shortly will be 33 of these air base groups, one at each of the major airdromes.

The air base group gives the Air Force Combat Command its mobility. It operates the permanent air field establishment so that the combat units can devote all their attention to combat duties. When the need arises, more combat units can "check in" for a day, week, month or longer, carry on their combat functions, and "check out" on a moment's notice.

It is intended that each Air Force be divided into two commands, the Bomber Command and the Interceptor Command, the former, as the name implies, comprising the light, medium and heavy bombing units, and the latter the squadrons of fighter and interceptor planes.

The Interceptor Command, for example, has direction of the mobile aircraft warning system and controls antiaircraft artillery, barrage balloons and searchlight units, in fact, has full control in the air above the area which it is charged with defending. It would order antiaircraft artillery at Hartford, Conn., where our own combat units are operating, to withhold fire and direct similar units at Camden, N. J., where only enemy forces have been reported, to let go with every gun available.

The Interceptor Command also will have considerable to do with the Air Warning Service now being organized throughout the country. Eventually this service will include a reporting net of more than 200,000 civilians living in every city, town and hamlet, trained to transmit information concerning the operations of enemy air forces which might penetrate our boundaries. This huge civilian force will be supplemented by Army plotting and reporting units manning the necessary apparatus.

(Continued on page 192)

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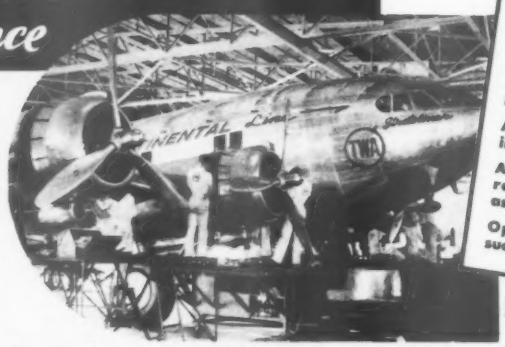

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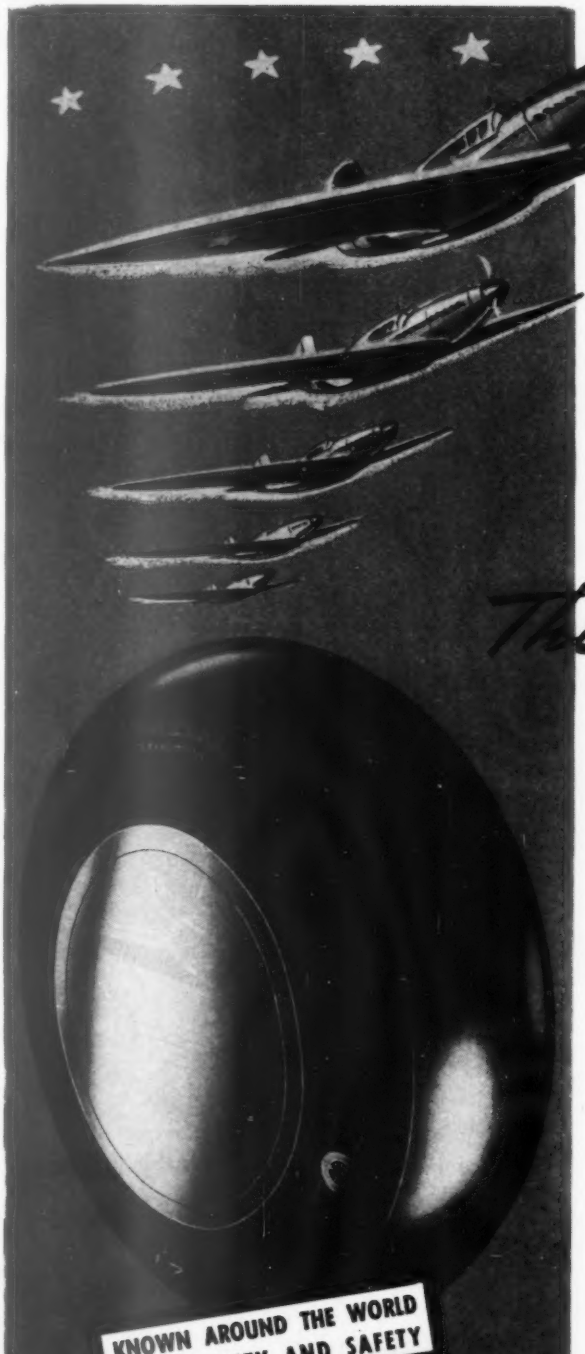

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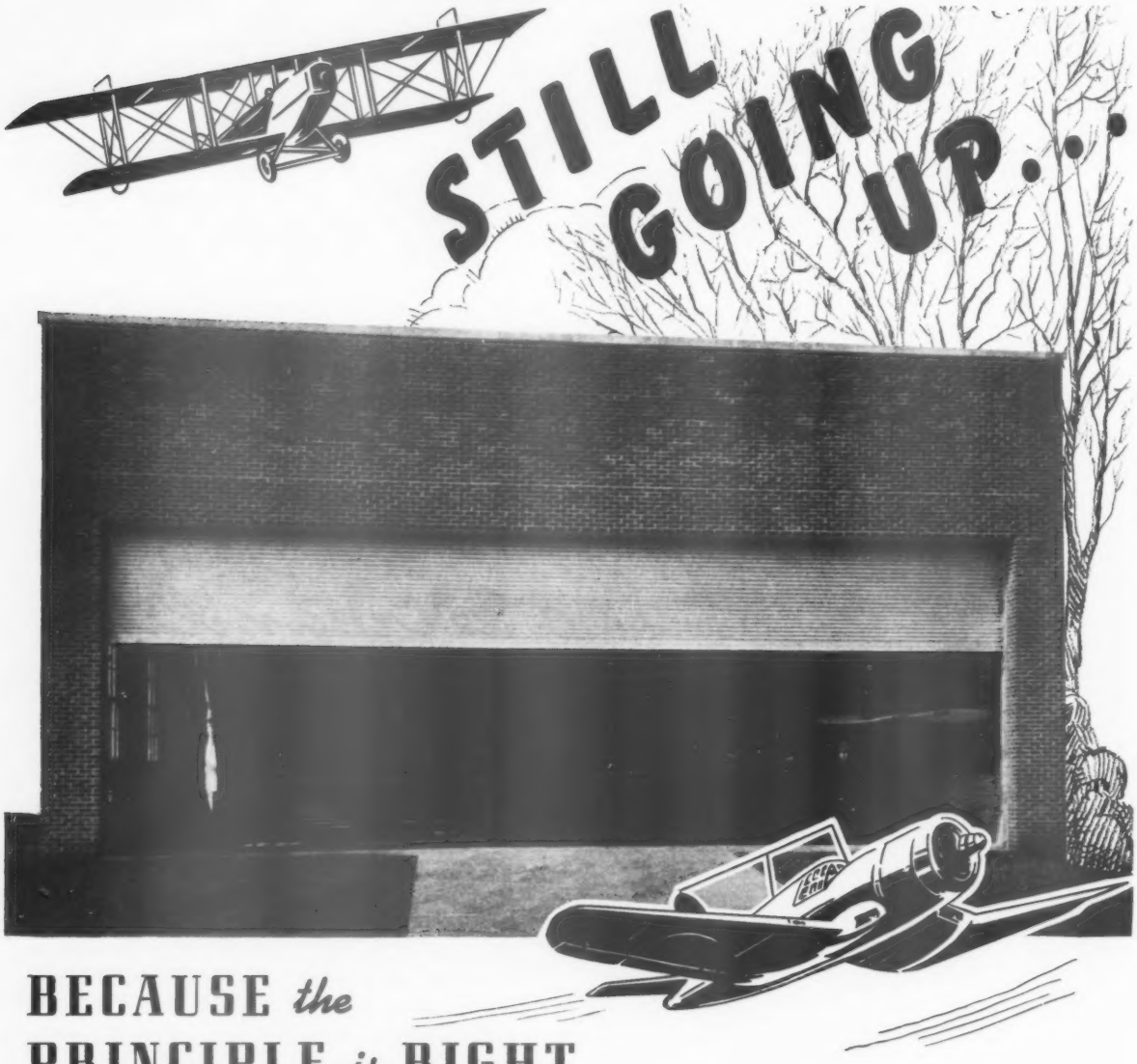

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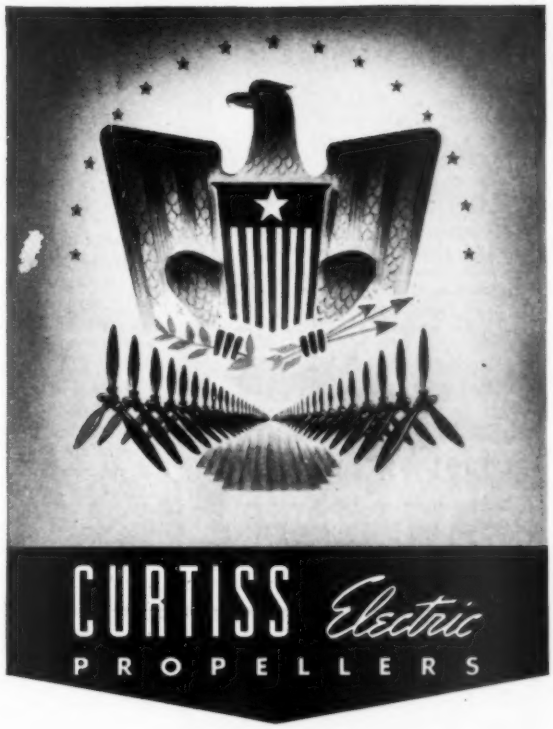

THE spirit of the Minute Men is roused again in America – but it takes more than a minute to make ready for defense today. Aviation, No. 1 Defense Industry, urgently needs men. Thousands are eager to answer the call but only a few are qualified – for Aviation must have trained men. That represents rare opportunity – opportunity to serve America and to find present and future opportunity.

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Contractors to U.S. Army Air Corps and Civil Aeronautics Authority

(*Continued from page* 188)

This civilian defense program is an additional job assigned to the Combat Command as a result of developments since the invasion of Poland. When first organized in 1935, there were three essential components of the Air Force Combat Command: airplanes, combat crews, and bases with their service personnel. The number of trained combat units able to take the air and operate effectively was the real measure of air power. The fourth component has been added as a result of operations of air forces against civilian populations and industrial and communications centers far behind the line of battle.

With the job of coordinating this fourth component, the Air Force Combat Command has attained increased importance and responsibility as a member of the national defense team. From a conglomerate mixture of combat units varying widely in proficiency standards and training status, it has progressed steadily into a homogeneous force capable of operating when needed in any theater of operations designated. Its effectiveness has been further increased by the securing of additional bases along our eastern perimeter of defense. While it is not yet the M-Day force the world situation may require, a sound foundation has been laid upon which a structure of the needed size can be built without confusion or disorganization. The current expansion program is rapidly correcting deficiencies in airplane strength, personnel and base facilities.

When first organized, the Air Force Combat Command was placed under the direct command of the Chief of Staff of the Army. The command was shifted in March, 1939, to the Chief of Air Corps, then again to the Chief of Staff and, recently, to the Chief of the Army Air Forces. Its commander has the rank of lieutenant general, the same as that of the commanders of the four field armies.

With its new strength in equipment, personnel and bases, the Air Force Combat Command will be better able than ever in its brief history to fulfill its role in the national defense plan. This role is clearly defined in the training regulations: to employ its power, mobility and striking force to assist the high command in accomplishing the national mission. A particular mission may require the Combat Command to provide close support for ground troops. Another time it may call for operations in coastal frontier defense. On occasions, the situation may require participation in joint operations with Army and Navy forces. Again, the strategy may make advisable independent operations beyond the sphere of influence of the ground or sea forces. Whatever the occasion may demand, whatever the type of mission assigned, the Air Force Combat Command plays its role as a member of the team, attacking those objectives whose destruction or neutralization is most essential to the success of the team as a whole.

In the selection of those essential objectives, the Air Force Combat Command has attained a considerable voice. In warfare, there is never a dearth of objec-

(*Continued on page* 216)

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In keeping abreast of the requirements of modern warfare, Uncle Sam's photographers have developed a new, high-speed processing unit that can be set up on the field of battle. Designed by Col. George W. Goddard, chief of the aerial photographic unit at Wright Field, Dayton, O., this portable tent enables trained darkroom specialists to develop and print their pictures within five minutes after they are taken. Don't fail to read all about the Army's "Blitz Darkroom" and how it can change the entire course of field maneuvers in the authoritative, brilliantly illustrated article beginning on page 20 of the big picture-packed

SEPTEMBER ISSUE

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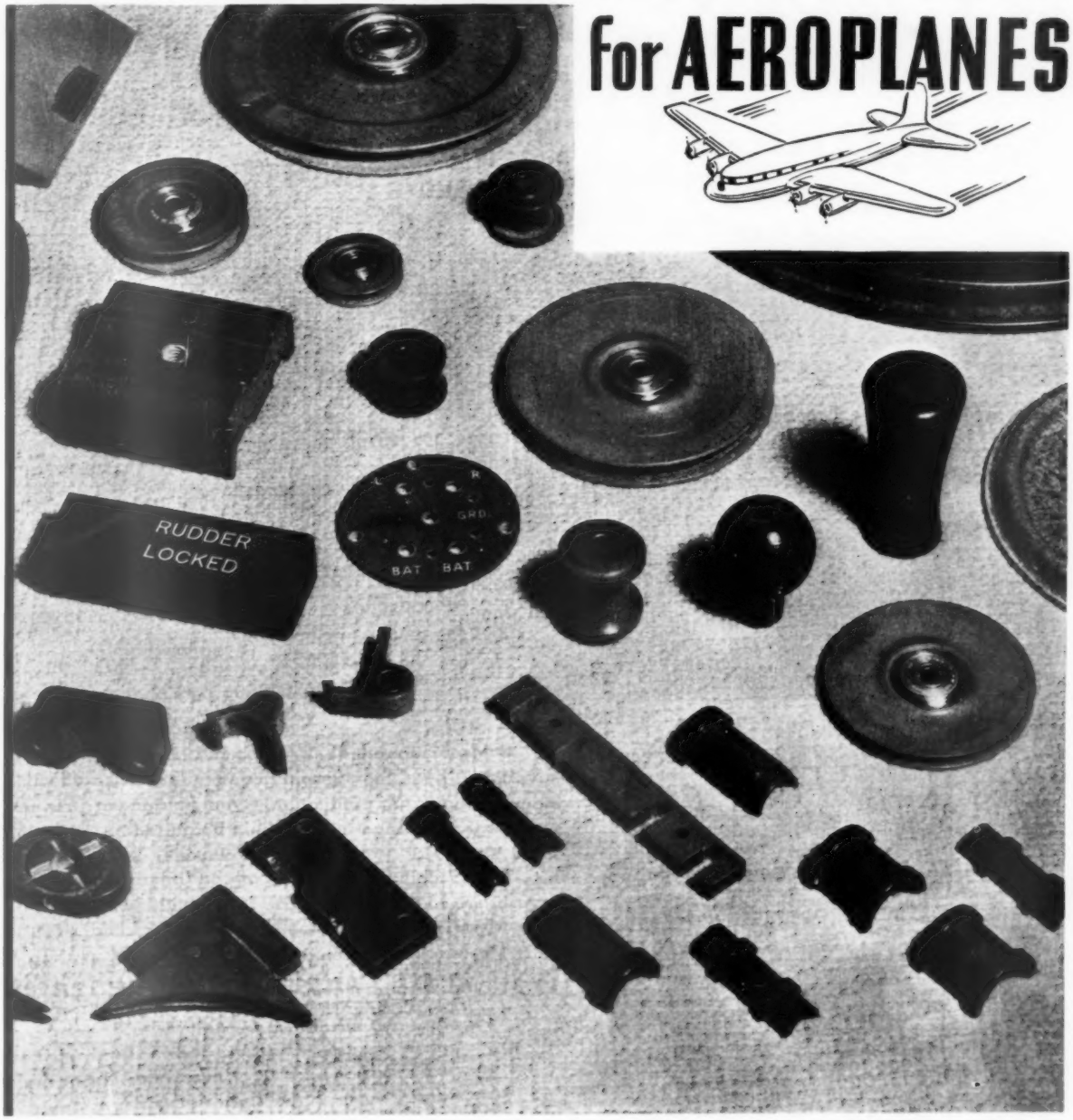

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Today's builders of both military and civilian aircraft also look to our reliable fabrics for wing coverings that will stand the strain of modern high speed flying. B*A*30—Grade A Airplane Cloth is widely used in both army and navy planes because of its remarkable uniformity, in strength, in weight, in thread count and in surface characteristics.

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UNITED AIRLINES SHUTTLE SERVICE

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Bill Turgeon, Mgr.

Air Bases

(*Continued from page 130*)

N. M.; Portland, Ore.; Everett, Wash.; Yakima, Wash.; Sunset Airport, Spokane, Wash.; and Salinas, Cal. Construction programs ranging from $350,000 up to $1,-350,000 were announced for various of these new bases and assignment of units to most of them also were announced at the same time.

Oct. 24, 1940, the War Department announced the creation of four—Northeast, Southeast, Northwest and Southwest—Air Districts, later known as Air Forces and an increase from the four wings then existent in the continental United States to 17 wings. Purpose of creation of the Air Forces was to effect decentralization of training and inspection duties of the Commanding General, GHQ Air Force. and to provide for development of commanders and staffs for such special task forces as may be required for operation in war. The Forces were under command of the Commanding General, GHQ Air Force. Headquarters for the districts were selected at Mitchel Field; Tampa, Fla.; Ft. George Wright, Spokane, Wash.; and Riverside, Cal.

The story of expanding airdrome and ground facilities in the continental United States has become far too voluminous to review. It is important, however, to note that on Dec. 3, 1940, the War Department announced that $25,000,000 was to be used for initial expenditures on Army garrisons at the eight base sites leased only a short time previously from Great Britain. The Chief of Army Engineers was to direct the survey and construction activities at all Army bases.

Preliminary work already had been started, it was announced, offices having been established by the Corps of Engineers at St. Johns, Newfoundland, and at St. George's, Bermuda. Additional field parties had been designated to sail for Trinidad, Jamaica, British Guiana, Antigua, the Bahamas and St. Lucia. A few days later, details of construction to cost $1,598,000 were announced for Puerto Rico.

In Alaska, the Air Forces is establishing its principal bases at Anchorage, on the coast, and at Fairbanks, across the high Coastal Range in central Alaska. The Ladd Field base at Fairbanks is serving primarily as a "cold weather" laboratory for all types of combat aircraft, clothing, lubricants and equipment. Similar cold weather training is in store for the ground forces assigned to protection of the Alaskan bases. Although single planes and small detachments were going to Alaska last year, the large scale movement of aviation outfits to the Alaskan bases really got under way early in 1941. Additional Army airdromes and other facilities for air defense are being established in Alaska, one of the earlier projects to get under way being a new field on Annette Island, near Metlakatla a few miles south of Ketchikan, southernmost Alaskan town of consequence.

Examination of a hemisphere map shows that the area within a 1,200-mile radius of United States air bases now in existence or under construction includes every mile of Alaskan and United States coast; the entire Pacific coast line from Point Barrow, Alas., to well down in Peru, and the entire Atlantic coast from near the mouth of the Amazon River to the mouth of Hudson Strait. It includes area from the southern tip of Greenland into Siberia.

As President Roosevelt said at the time the United States acquired the right to establish bases—air and naval—in Newfoundland, Bermuda, the West Indies and in British Guiana, "It is an epochal and far reaching act of preparation for continental defense in the face of grave danger."

Truly, the Air Forces face the task of defending broadened horizons.

END

Greenland Studied

INFORMATION on Greenland appearing in publications in 13 languages is being indexed by the WPA for the Army Air Corps. The project is sponsored by the State Department and is under the technical direction of Dr. Vilhjalmur Stefansson, noted Arctic explorer.

Maj. Gen. H. H. Arnold, Chief of Air Corps, says: "In my opinion this bibliography will be of advantage from a defense standpoint because of its use in study and preparation of possible military operations, especially air operations, and of meteorological conditions which are important in such operations."

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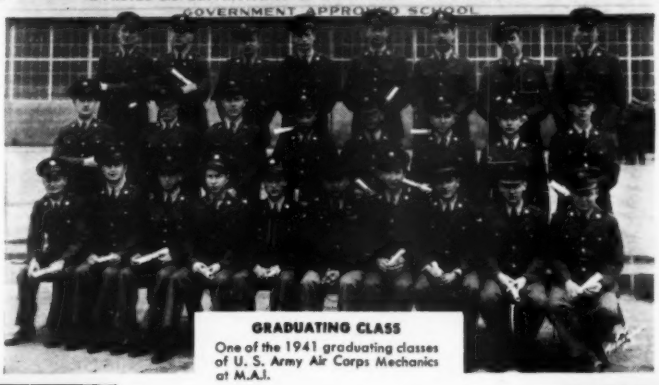

GRADUATING CLASS
One of the 1941 graduating classes of U. S. Army Air Corps Mechanics at M.A.I.

CAPTAIN CHAS. D. DAILY
Commanding officer U. S. Army Air Corps detachment stationed at M.A.I.

MOTOR DEPARTMENT
Wasp motor on testing block.

CARBURETOR DEPARTMENT
Student assembling a carburetor.

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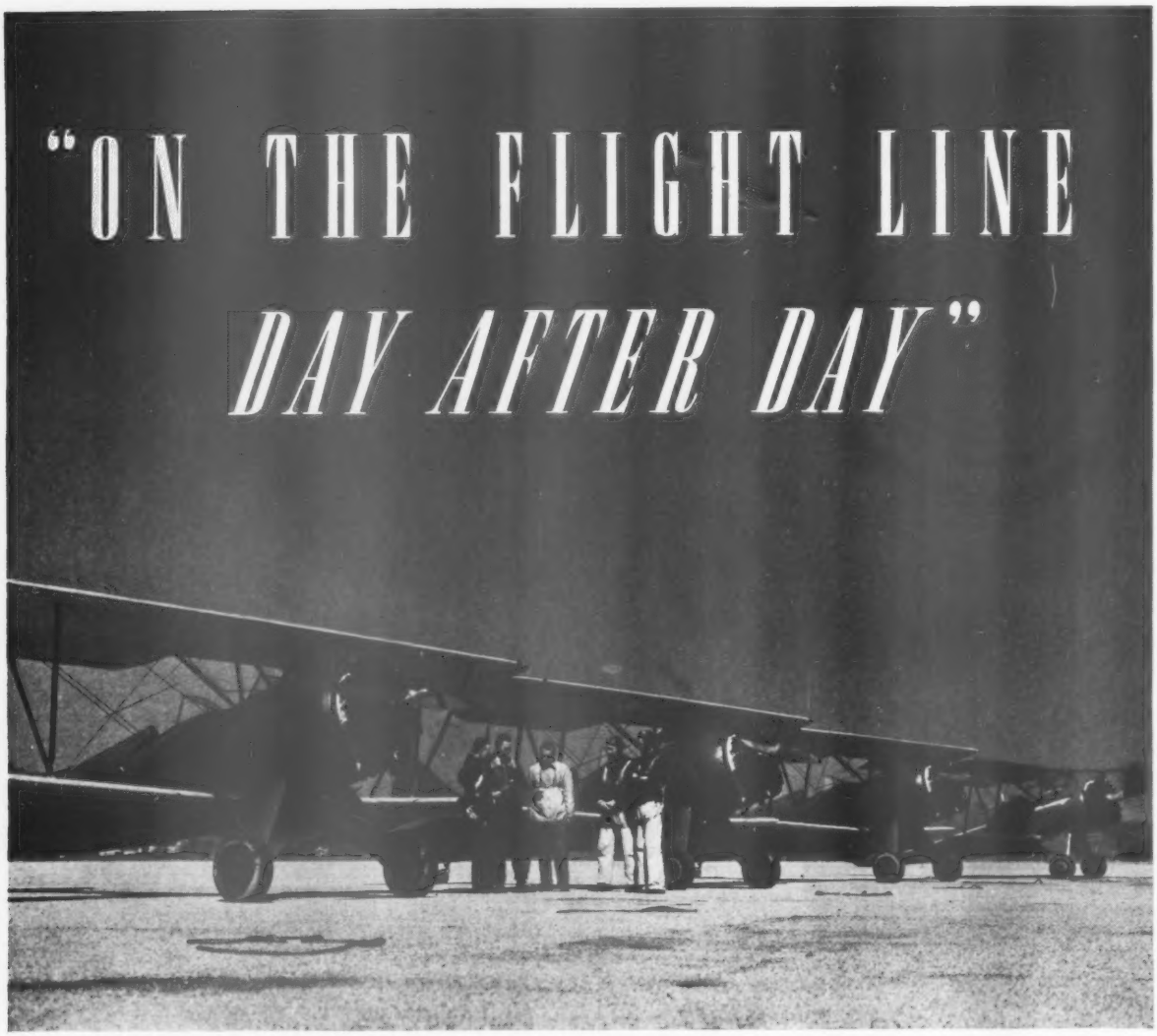
← **AIRPORT**

Aerial view of Kansas City Municipal Airport. Buildings in center left are quarters of U. S. Army Air Corps Mechanics while students at M. A.I.

AIRCRAFT ELECTRICAL SYSTEMS DEPARTMENT →

Electrical inertia starter set up on a hydraulic porny brake for testing the torque of inertia starters.



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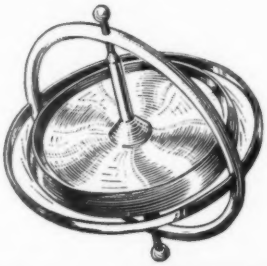
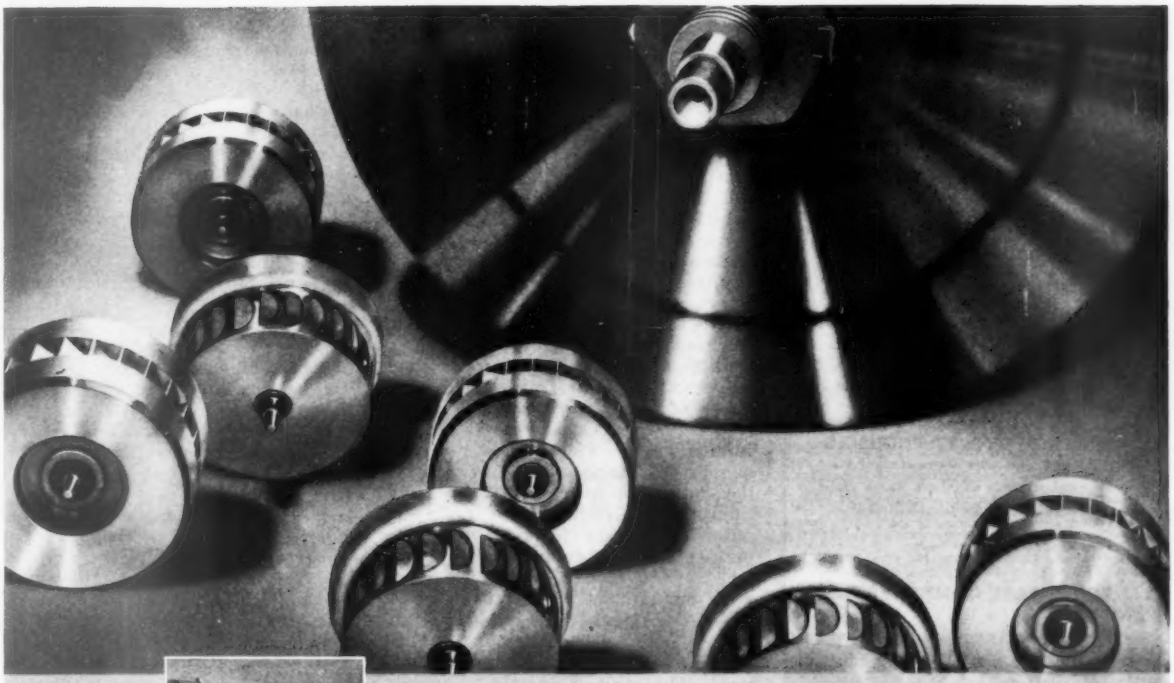
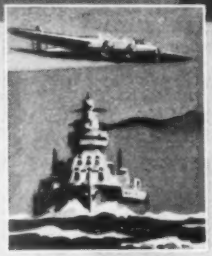


for National Defense





Aboard every major vessel in the United States Navy, the Army, the Coast Guard and the auxiliary services, in the cockpit of every Army and Navy combat plane, spinning tops are serving the National Defense. The natural phenomenon of the gyroscope has been harnessed to provide America with some of the finest navigational equipment in the world.

At sea, Gyro-Compasses — spinning tops of the highest order of perfection — have made possible *true north* navigation and the wonders of automatic steering. In the air, whirling metal rotors in the Directional Gyro, Gyro-Horizon and Automatic Gyropilot have revolutionized instrument flying.

Since Sperry put the spinning top to work thirty years ago, many Sperry developments which do not make use of the gyroscope have also achieved places of vital importance in the National Defense. They include the Anti-Aircraft Searchlight, the Sound Locator and the Universal Director.

SPERRY GYROSCOPE COMPANY, INC.

BROOKLYN SPERRY ***NEW YORK***

Production Engineering

(*Continued from page* 119)

ordered from their drawing board designs. Brig. Gen. George C. Kenney, assistant chief of the Materiel Division said recently:

"One of our newest bombers was ordered built after we saw it on the back of an envelope and 18 months later the ship was flying."

Wright Field, where all new planes are tested, takes delivery on the first ship off the production line, runs it through gruelling tests which ascertain its maximum speed, range, maximum rate of climb, ceiling, landing and take-off runs, and other vital data to see if results equal Air Corps specifications. If satisfactory, several of that model are ordered and a new test program follows. The Army calls this routine "accelerated tests," and has set up a special section at Patterson Field, near Dayton where the tests are carried out. Production Engineering has jurisdiction over the program.

For the accelerated tests, pilots and crews of tactical squadrons are brought to Patterson Field. The ships are flown night and day for 150 hours, simulating actual combat conditions. The small fighters get different treatment than do the bombers. Pilots literally "yank" them all over the sky in every conceivable maneuver. They fly them full-throttle, half-throttle, fast, slow, high, low for those 150 hours—equivalent to more than a year of service for the airplane. Bombers are loaded up with heavy duds to simulate bomb loads, gun crews, radio operator, pilot, co-pilot, go aboard and the big ships are flown for as many as 18 hours non-stop at high altitudes to test them under regular bombing conditions.

The accelerated test program calls for testing of all tactical types during a specified period. Previously bombers, pursuits and trainers each underwent tests at separate intervals. That is, competitions were held for the various types at certain periods during the year and only those types were tested during those periods. Whereas the former test routine took several months, the present program cuts the time more than one half.

Stepping up the test routine, was just the beginning. The Army found many shortcuts for getting streamline procurement. Originally, a manufacturer seeking a contract for a military airplane was required to submit one finished prototype. This was shortened so that manufacturers had to submit only designs of their projected planes. But legal requirements for the design competitions required a three-months' period of advertising in advance of submission of the design until, in June, 1940, Congress passed an Act authorizing purchase of military equipment without competitive bids.

The Contract, Industrial Planning and Production Engineering Sections at Wright Field work together. Contract, earmarks the money and gives authorization. Industrial Planning, provides space for plants and workers while Production Engineering supplies the airplane with all latest improvements for the production line.

The Facilities Expansion Branch of the Industrial Planning Section has project-engineered the expansion of some 80 plants ranging in cost from $38,000 to $56,000,000. This branch analyzes and evaluates every cost applying to industries asking Government aid for expansion in order to meet deliveries scheduled for the Air Corps. It decided that the project will be adequate and suitable

(*Continued on page* 208)

Cargo and Transport

(*Continued from page* 127)

needs a new engine for one of its P-39's. The station supply officer at Selfridge Field would make out a requisition for the engine, forward it to the depot supply officer at Patterson Field by radio, since Selfridge is within the Patterson Field (Fairfield Air Depot) control area. The supply officer at Patterson Field delves into the supplies and obtains a new engine, or an overhauled one that is as good as new, and and prepares it for shipment to Selfridge. He then turns it over to the air-freight terminal of the transport group. He advises the group operations officer, who assigns a pilot and a ship to fly it to its destination.

Depending on the freight balances reported at the main air depots, weekly flight schedules are made up in advance covering major scheduled flights for the week. This basic schedule, made up at

(*Continued on page* 202)

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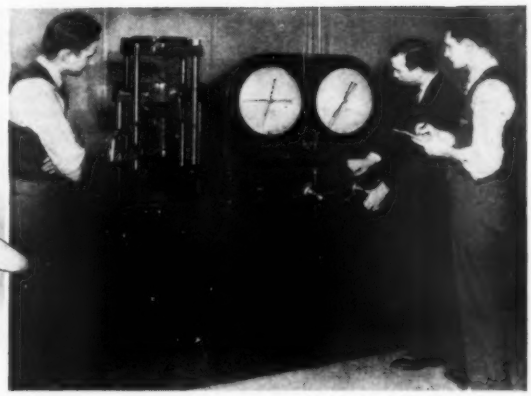

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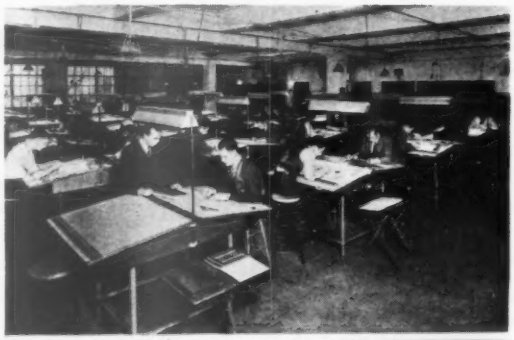

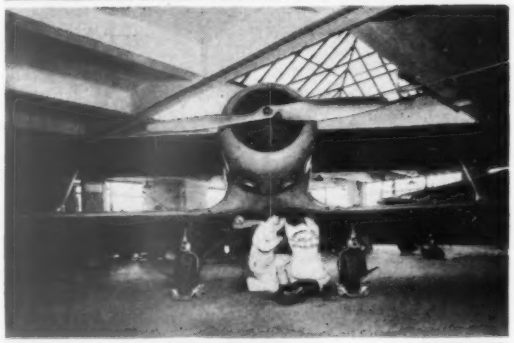

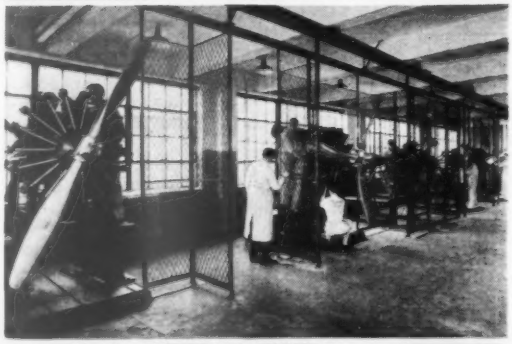

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(*Continued from page* 200)

wing headquarters, Wright Field, leaves enough cargo space unallotted to handle emergency orders. Radio communication is maintained with the depots. Arrivals, departures and amount of cargo on board are stated in the messages, providing headquarters with a constant picture of each transport plane's approximate position and its payload at all times.

Just as it is the task of the transport squadrons to keep the tactical units in the air, ground units must keep the transport units in operation. For each Air Corps transport plane in the air, there must be six or seven men on the ground to maintain it. A crew chief is assigned to each plane within the squadron. He is responsible for the airplane and its records, under the direction of the line chief and the engineering officer. All maintenance personnel in the group are pooled together, regardless of squadrons, and divided into eight-hour shifts. On each shift are experts in propeller maintenance and adjustment, ignition, hydraulic brakes, landing gears and instruments. Several expert mechanics, under the crew chief's direction, are assigned to the various tasks. Each ship is checked, repaired and adjusted until it is in top-notch condition to fly again. When the crew chief's airplane is on a flight, he works with the other maintenance crews.

This is a comparatively new system of maintenance and is working splendidly so far. The ship is test-flown by the engineering officer or his assistant before it is placed at the disposal of the group operations officer for scheduling.

The new repair system was originally started early this year at Patterson Field and has since been adopted by all transport groups throughout the U. S.

A loading crew, trained in loading transport planes properly so that the load will not shift in bumpy air, is maintained at each depot. Correct loading technique was attained after several years' observation and cooperation between pilots and ground crews. In transport aviation's pioneer stages, many accidents resulted from poorly-loaded planes.

All airplanes are checked and rechecked after each flight. They are overhauled on an average of once every 2,000 hours. Brought to repair depots, they are completely torn down, old parts thrown away and new ones substituted until they are as good as new before they depart on another 2,000-hour phase.

The 10th Transport Group has the enviable record of no casualties on scheduled freight runs, despite flying in all sorts of weather, along uncharted routes and into little-known air fields. Because passengers are seldom carried, Air Corps transports fly when others cancel out.

END

Air Corps

(*Continued from page* 68)

This is quite as it should be, because the housewife is not looking for glory, neither is the Air Corps. The housewife has heavy demands made upon her by all members of the family, and she takes her satisfaction in keeping a roof over the heads of her family—feeding them, clothing them, seeing to it that they are properly schooled and made ready for their work in life.

She may not be a glamor girl, and this pleases her because she does not desire to be a glamor girl; she would rather the members of her family turned to her with their problems, and their difficulties, and their emergencies than that she be glorified above and beyond her just deserts.

There is little that is glamorous, little enough glorification, in most of the work of the Air Corps. It is for the most part just work, and then more work, and then still more work. As it grapples with its terrific job, with its heavy responsibilities, and solves some of its manifold problems and fails to solve others, only to start from scratch and try again, its back may be bent under the increasing load, but its heart is light.

Its heart is light, because no matter what harder tasks the future may have in store, the Air Corps can say with Kipling: "After me cometh a builder tell him I, too, have known."

END

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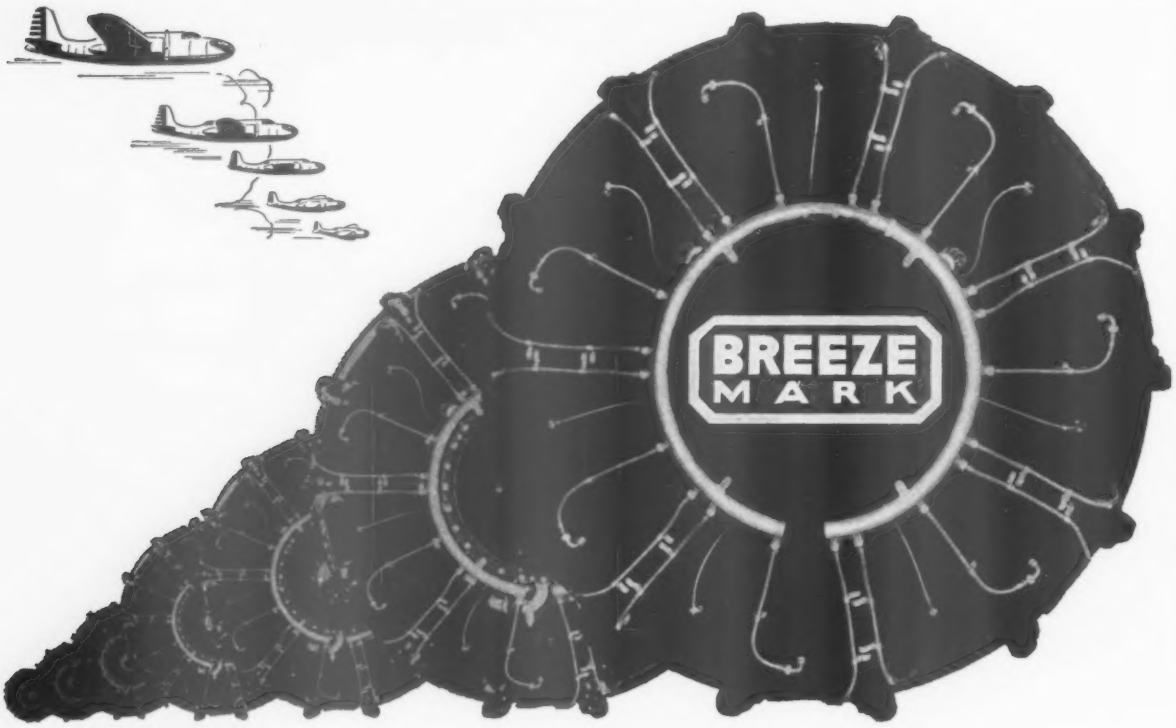

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Air Forces Publicity

(*Continued from page* 138)

the place to keep the news from the folks back home. Promptly, the local public relations officer invited newspaper reporters and photographers to visit the center and check first hand on the story. The visit was paid, stories were printed disproving the rumor and the whispering campaign died. The importance of such activity is self-evident.

When the expansion of the Air Forces was undertaken and the training of thousands of new flyers began, there were a number of fatal accidents. As reports of deaths increased, wild stories and baseless charges began to circulate. The Air Forces Public Relations Office in Washington decided to step in. Representatives of news gathering organizations were invited to a War Department press conference. A high-ranking Air Forces officer explained in detail the reason for the crashes and pointed out that a certain number of deaths were inevitable in any training program. Soberly, he warned that the number of accidents would increase as the number of students increased. The frankness of the statement and the truth of the situation made a good impression. The public had been taken into the Army's confidence and there has been no more misunderstanding on this score.

Although there are certain matters which the Air Force has designated as confidential and which are not publicized—lest they betray secrets—, there are times when the Public Relations Section must get around the policy to give the people the facts. This spring, for instance, there appeared a number of charges that the *Flying Fortresses* were so slow that they were obsolete. The speed of planes is information which the Air Forces no longer makes public, but the repeated charge that this plane—which most of the country looked upon as one of our

(*Continued on page* 214)

Reconnaissance

(*Continued from page* 66)

can be adapted for observation purposes in an emergency.

An observation plane's crew is made up of highly trained specialists. Air Corps observers are now being trained at Brooks Field, Tex., some being drawn from many branches of the service other than the Air Corps.

In a two-place observation ship, the observer must be a man of many talents. He must be a photographer, a radio operator, a navigator, a machine gunner, an expert on ground force tactics and an authority on day and night reconnaissance.

Experience has shown that good observers are born, not made. But good observation and reconnaissance services *are* made—they don't just happen. And in today's warfare, you'll find that the winning army, along with other things, has had the sharpest eyes.

END

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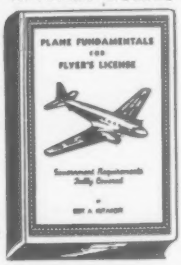

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Experimental Engineering

(*Continued from page 86*)

check flights, made by pilot engineers who put the plane through almost every conceivable maneuver to check its performance against specification requirements, as explained in another article. This particular test-flying unit is headed by Maj. Stanley Umstead, who recently flew the B-19.

Under the pre-emergency arrangement at Wright Field, once the first experimental prototype plane had successfully passed its ground and flight tests and was approved, an order for 13 planes was given. These were placed with regular tactical squadrons for a year of service test flying.

Now, however, while the first plane is being tested, additional planes are streaming off the assembly lines. As promptly as possible, under a new accelerated service test program, more of the new planes are brought to adjoining Patterson field, here, and are given a heavy course of virtually continuous flight by relays of ordinary pilots, picked at random from squadrons at other Air Corps fields. In three weeks each plane gets the equivalent of a year's flying under normal conditions.

Changes recommended are made "on the run". In other words, the Air Forces "freezes" production on a certain large quantity of the planes so that the flow will be continuous until everything is ready to make the desired improvements with minimum interruption. Additional changes may be made from time to time, at intervals, as long as the Air Forces continues to order that particular airplane and up until a new design comes off the drawing boards, leaving our once revolutionary model still obsolete despite all its later improvements.

END

Production Engineering

(*Continued from page 200*)

for the production intended and that the output for each project is at least standard for its type of industry.

Problems of tax amortization under which companies provide their own capital to finance national defense expansions and are permitted to deduct the cost in five annual installments from their gross income also are handled by this branch, which, to date, has analyzed and certified for approval expansion of some 360 manufacturers who will receive these benefits.

To insure that each manufacturer will meet Air Corps specifications in his contract, an inspection section at Wright Field maintains inspectors in the various plants to check the work in various stages of production. Recently a new phase of the inspection work has been added by establishment of Government inspectors of plant protection, to insure that each Government contractor maintains an adequate force of plant guards and exercises proper fire and police precautions to guard against sabotage or accidents.

Charged with the main responsibility of seeing that production schedules in the various plants are met or exceeded also is part of the job. Various branches within Production Engineering are charged with the handling of production on all types of aircraft and equipment including bombardment, observation, pursuit, transport and training airplanes and

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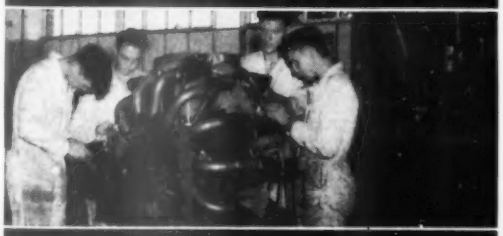

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Specialists in each of these branches keep in close touch with progress of the various Air Corps contracts. They visit the manufacturing plants, receive reports from the plants and hold frequent conferences at Wright Field with representatives of the manufacturers. Through this organization production of airplanes and accessories is coordinated into an even flow and production bottlenecks, such as the recent lack of propellers, are spotted quickly and remedies sought.

Coordinating the study of production progress is the Production Survey Unit which keeps a record on the production of planes and equipment by all Air Corps contractors, so that key statistics on the entire industry are available at once for any future planning. The survey unit is closely interlinked with a unit of the Office of Production Management.

The OPM unit is called the Aircraft Industry Scheduling Unit and has charge of scheduling supplies of materials and machine tools to the various aircraft manufacturers in accordance with their needs. Also, they see to it that raw materials do not pile up at one plant which hasn't the personnel or machines to process it, while another plant remains idle because of lack of materials.

Standardization also has simplified the inspection work of both services and removed duplicate inspections to a large extent. Under the new plan one of the services will take control of all Army and Navy inspections at a given plant. The other service provides a representative who will act as advisor to the controlling service and as liaison representative between the manufacturer and procurement headquarters. As a general practice, the service with the larger volume of orders at a plant, becomes the controlling authority for inspection in that plant.

END

Radio

(*Continued from page* 96)

instruments to see that the system is functioning properly, rather than actual manipulation of the controls.

As head of the Wright Field instrument-navigation laboratory, the author was one of the three men to make this first automatic landing. His civilian associate, Raymond Stout, is continuing in research work in the laboratory, while the third man, Maj. Carl J. Crane, now is transferred to another laboratory. Another important personality in the instrument-navigation laboratory is Maj. Thomas L. Thurlow, probably the best-known navigation expert in the Air Corps. Thurlow was co-navigator for Howard Hughes on his record-breaking four-day 'round-the-world flight in 1938. Hughes gave large credit to Thurlow for the success of the speed dash. Since that time Thurlow has retired into the laboratory, but has had an important part in developing some of the new navigation aids with which the Air Corps is being equipped.

END

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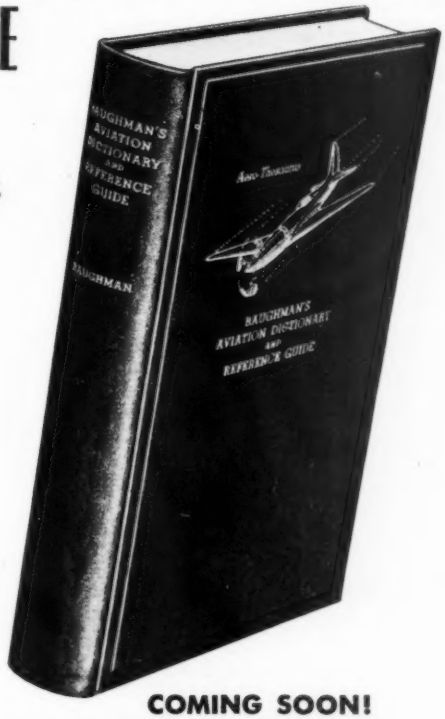

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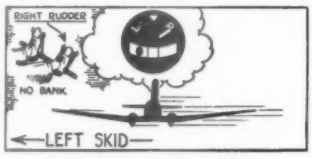

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Air Forces Publicity

(*Continued from page* 206)

mightiest weapons—was obsolete began to have a dangerous effect. The Air Forces suspended the rule and told the public what the speed of the four-engined bomber was, proving that it was fast enough to stand up in modern combat.

The Public Relations Section of the Air Forces was not organized as a ballyhoo nor as a propaganda agency. To conduct activity of this nature would defeat the purpose for which it was set up, because such information is intended to deceive the public and, while it may make a good impression at first, it will fall of its own weight eventually. The section was organized, rather, along the lines of the public relations bureaus maintained by almost all large industrial firms—to keep the public confidence and tell the Army's story.

All Air Forces public relations activities are coordinated with those of the War Department's large Bureau of Public Relations. The War Department bureau is headed by Maj. Gen. Robert C. Richardson, a distinguished officer who is highly regarded by Washington newsmen. Major General Richardson won the Distinguished Service Medal for activities during the Meuse-Argonne operations during the World War and holds the French Legion of Honor and numerous other decorations from foreign governments. The deputy director of the bureau is Lieut. Col. Royal B. Lord.

The War Department bureau has eight branches: Administrative, under direction of Lieut. Col. R. B. Lovett; Press, under Lieut. Col. Stanley J. Grogan; Pictorial, under Lieut. Col. Frank A. Allen, Jr.; Special Assignment, under Lieut. Col. Francis V. Fitz Gerald; Planning and Field Liaison, under Lieut. Col. R. Ernest Dupuy; Intelligence and Analysis, under Capt. Reginald Looker; Procurement Information, under Lieut. Col. Robert Ginsburgh; and Radio, under Edward M. Kirby. Among other press contact officers are Maj. Frank Miller and his assistant, Lieut. Robert Kinkead.

The press and pictorial branches are probably the largest. The pictorial branch handles arrangements for still and newsreel pictures of Air Forces activities.

Secretary Stimson, in speaking to a group of public relations officers brought into the War Department from all parts of the country for a conference on their new duties, warned that the hundreds of thousands of men in the Army "are intelligent and will wish to know the reason for all they are asked to do.

"You cannot fool them, but you must help them to understand the purpose of their new life and you must recount fairly and truthfully its progress to the people who support them at home. If you do that, the men in the Army will carry through and the men and women at home will back them."

Napoleon laid down the axiom that an army travels on its stomach. The United States is building an Army and Air Forces that must travel also on its brain; the public relations officers are responsible therefor.

END

Armament

(*Continued from page* 94)

dividually or all at one time. A special selector panel has been designed that allows the pilot to fire any gun he chooses. This firing mechanism is controlled electrically. Panels were developed by the Fixed Gun Unit.

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around their guns, not the guns around the planes. Literally we are building guns and putting wings on them.

The words of Nathan Bedford Forrest, Civil War general, who said: "He what gets there fustest with the mostest guns, wins" are very much alive.

END

Combat Command

(*Continued from page* 192)

tives whose destruction or neutralization would advance the plan of operations in greater or lesser degree, many of them tempting and vulnerable. The choice among them is a matter of careful consideration by commanders thoroughly experienced in air operations. The selection of an objective or objectives which are most vulnerable as well as vital may determine the success or failure of an entire operation.

The scope of the Combat Command is constantly being extended by the development of airplanes of greater range and carrying power. The pursuit, reconnaissance and bombing missions in coordination with other forces are essential to success of the team as a whole. However, the range and speed of the modern airplane has greatly influenced flexibility in the choice of targets, giving the Air Force Combat Command its greatest scope, perhaps, in independent bombing operations.

The Army Air Force is a powerful weapon. The Air Force Combat Command is its keen edge. For whatever purposes the Army Air Forces are to be used it will be the Air Force Combat Command that will do the actual fighting. It is for this purpose that the Air Force Combat Command exists and it is toward this end that the training of men and units and the establishment of bases are being carried forward with all the vigor of which we are capable today.

END

Aero Medical

(*Continued from page* 90)

attempt to control airplanes which have the speed and the ceiling to cause their deaths.

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END

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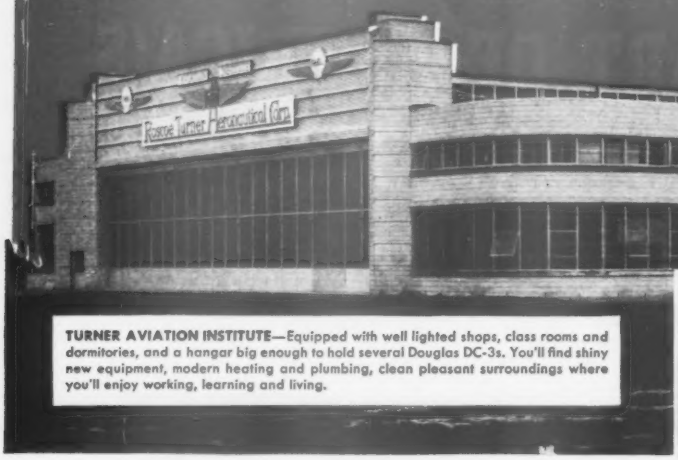

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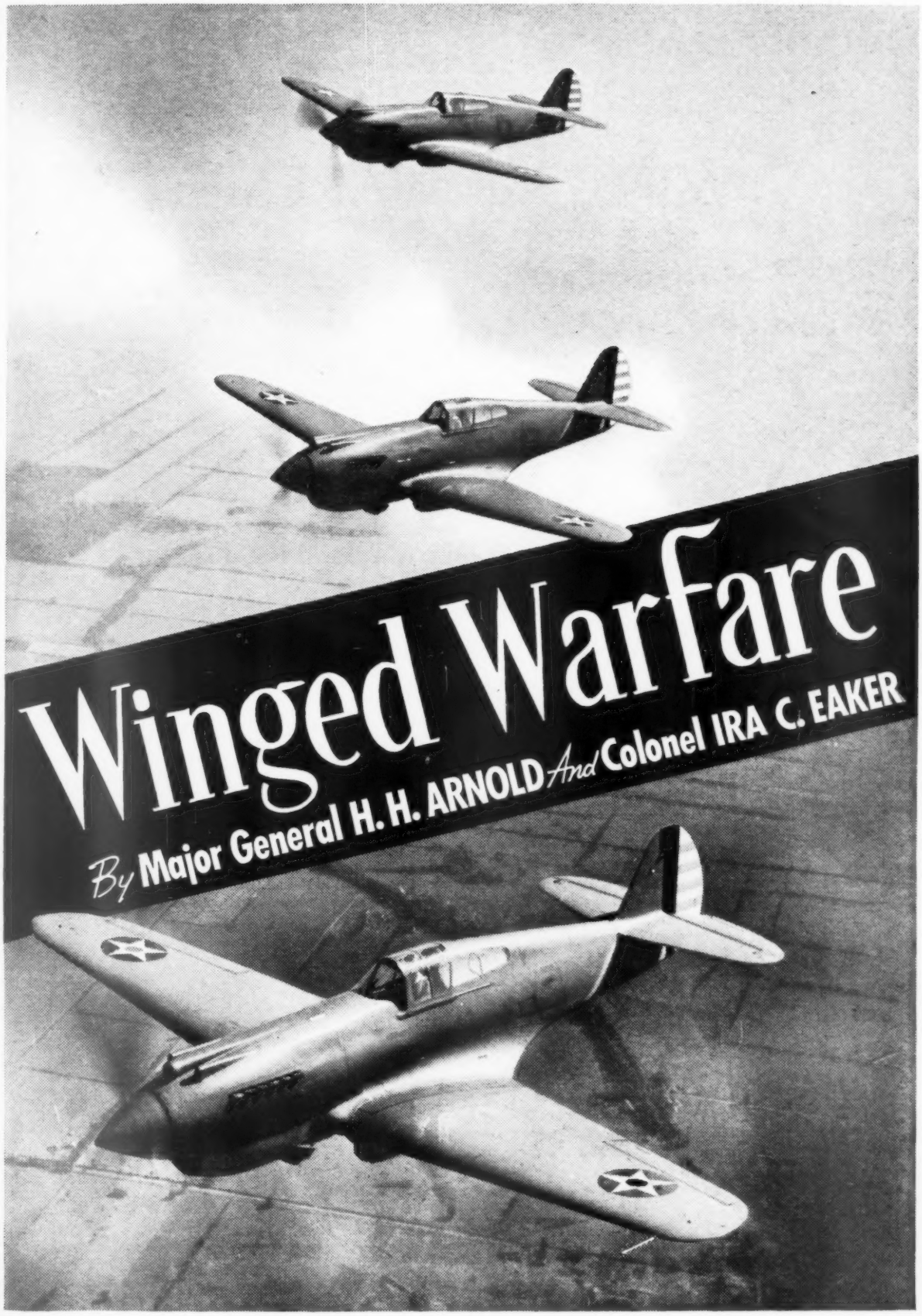

Winged Warfare
By Major General H. H. ARNOLD And Colonel IRA C. EAKER

The Authors of WINGED WARFARE

Maj. Gen. HENRY H. ARNOLD

Col. IRA C. EAKER

General Arnold graduated from West Point in 1907 and promptly joined the infantry. Four years later he was assigned to the Air Corps, which then consisted of one plane and a handful of pilots. He was one of the Wright brothers' first students and holds Pilot License No. 29 and Expert Aviator Certificate No. 4. Twice during his flying career he has been awarded the Mackay Trophy; he also holds the Distinguished Flying Cross. Since 1935 General Arnold has successively been commanding officer of the Air Corps' First Wing, Assistant Chief of the Air Corps, Chief of the Air Corps, Deputy Chief of Staff for Air and, recently, Chief of the entire Army Air Forces.

Colonel Eaker also began his military career in the infantry. He was detailed to the aviation section of the Signal Corps in November, 1917, and has been flying ever since. In 1926 he was a pilot in the Army's Good Will flight around South America. In 1929 he set a world's endurance flight record as chief pilot of the *Question Mark*. In 1936 he made the first transcontinental blind flight and, in 1939, made two non-stop transcontinental flights, refuelling in the air. He also holds the Distinguished Flying Cross with Oak-Leaf cluster, many citations for outstanding service. A Texan, he is 45, holds a journalism degree from the University of Southern California.

★ ★

Dedicated by the authors to

the intrepid and courageous flyers of Britain's Royal Air Force, whose matchless exploits in the skies above Europe deserve the praise of the civilized world, this volume is dedicated in admiration and respect—admiration for the boldest battles yet fought in the air, respect for fearless airmen for whom duty is the Holy Grail.

The abridged version of "Winged Warfare" which appears in the following pages is adapted from the original volume recently published by Harper & Brothers, New York ($3.50) and is presented by special arrangement.

WINGED WARFARE

Chapter One

WINGED WEAPONS

"The lessons of this war are ours for the taking. Machines today are more important than men. I have always been of the opinion that if Mr. Chamberlain had had 5,000 first line planes at home when he conferred at Munich, we would have truly seen 'peace in our time.'"

—Ambassador Kennedy

FROM the age of the Greek triremes and the Roman legion to this war-wearied time, the world has been overrun and scourged by some conqueror with a new weapon or with a new use for an old weapon. The leader with a new twist to tactics or a new use for old weapons in his strategy was invincible until he had run his course or time had cut him down. There is no older lesson in military history.

Now, in our time, the rampant conqueror is Hitler; the new weapon is the airplane.

In 1914, but little more than a decade after the first heavier-than-air flight, the more daring military leaders, using their initiative and imagination, were able to visualize the airplane as a new weapon as war broke savagely on battlegrounds centuries old. During the four turbulent years of that World War conflict the number of military airplanes in the combatant nations increased from less than 1,000 to more than 10 times that number. Aircraft did not, however, play the leading role in that conflict. Armies and navies settled that issue. There were some signs in the later days of that struggle which indicated that the next general war, if delayed a few years, might produce an important if not decisive air phase. These portents not plainly written, however, were largely overlooked by many of the foremost strategists of the world.

So far as is known, but three world-known military leaders came away from the first great war with a conviction that a new weapon, vital to modern warfare, had come into existence, and that the airplane was that weapon. One of these was our own Brigadier General William Mitchell. Another was Hermann Goering, now Marshal of the Reich. The third was Adm. W. E. Sims, United States Navy.

General Mitchell came back to a nation which was tired of war, a people which had made a costly sacrifice and wanted to forget it. This was not a fertile soil for his teachings and pleadings for air power, and the time was far from ripe.

Hermann Goering worked under different conditions and upon an entirely different people and received a more attentive hearing. His people were smarting under the lash of adversity. Peace treaties closed opportunities to them for great armies and superior navies. They must turn to another expedient in order to rise from defeat. Goering proposed air power. A new German political school was just emerging and it seized upon his suggestion. The bloody sequel to this story is now being written in the skies above Europe.

What the final answer will be on the power and effect of the airplane in war no man now knows, but it should be read by every citizen of the world hot off the press. One thing already is clear, if the point of this sharp, new weapon—air power—is to be blunted, an anomaly will have appeared.

Reichsmarschall Hermann Goering led Germany's aerial rearmament.

Adm. W. E. Sims, U. S. Navy. He predicted air power's future role.

Brig. Gen. William Mitchell, U. S. Army, begged for action far ahead of his time.

Development of the Bell "Airacuda" (YFM-1A) has been hampered by lack of liquid-cooled engines of sufficient horsepower. This multi-place fighter is in a new category set up by Army aviation men.

The airplane may become the antidote to the air menace. The air fighter we know to be the stout shield which turns the bomber spear from the heart of mankind.

THE MILITARY AIRPLANE

The airplane was not always a military weapon. Undoubtedly it is one of the great sorrows of the father of flight, Mr. Orville Wright, to find his brain child turned to nefarious uses. Alert military men early realized, however, the latent possibilities of the airplane to bring new speed, new vision and new range to warfare. Some of the earliest students of the Wright brothers were officers of the United States Army. What could have been more natural than for these young lieutenants, after learning to fly, to carry machine guns, to put early radio sets in their frail craft and practice shooting from the air and sending messages to troops on the ground?

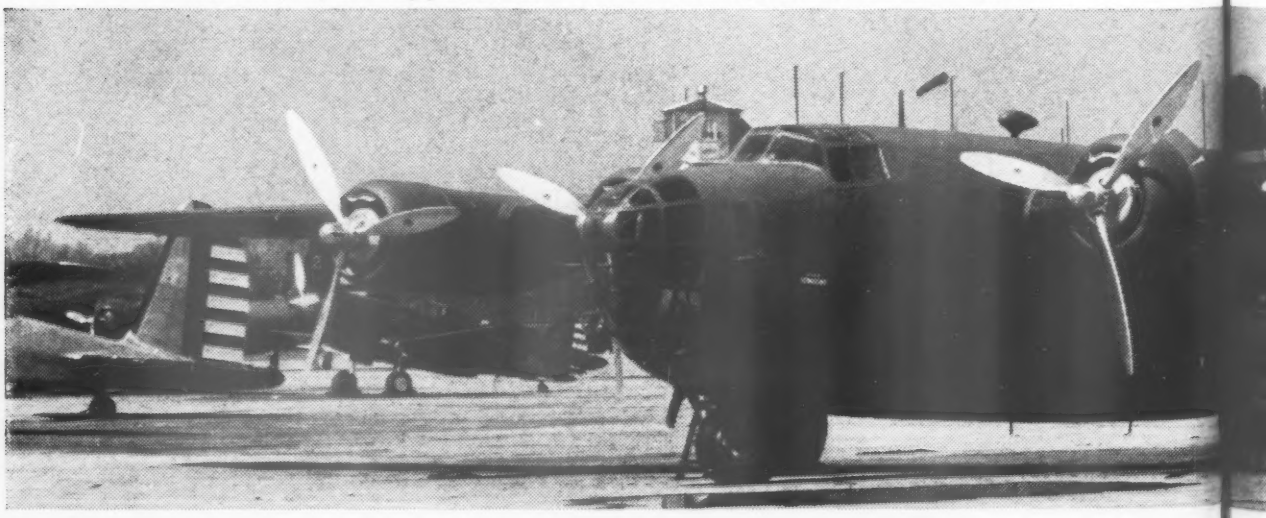
Now as we look back upon those early days in aviation it seems strange that all military leaders in all nations of the world did not realize at least the powers of extended vision and better communications and the increased influence of command which become possible, even with the earliest of those box kite airplanes. True, they could fly but 40 m.p.h. and could climb but a few thousand feet. But what a difference it would have made in warfare, looking back over history's campaigns and battles and combats, if the leaders could have seen a few more miles or could have delivered a message a little faster than the speed of a horse. If General Custer had had even the earliest of the Wright flyers flying above him that morning in the Black Hills, he would not have been ambushed at the battle of the Little Big Horn. If Napoleon could have reached Blücher by aircraft, even at 40 m.p.h., he might not have lost the battle of Waterloo.

We are less likely to condemn the old military masters for lack of vision and foresight at the turn of the century, when we remember that the Wright brothers were flying for several years almost daily at Dayton, O., before the American public, generally, realized that human flight was possible.

Although surprising on some counts, it is none the less understandable now why so little use was made of the airplane during those 10 years from the first successful flight at Kitty Hawk to those dark days in August, 1914, when two great battle lines moved together from Verdun westward to the sea. The exigencies and emergencies of that conflict, the first great war, raised the curtain on the air era in armed conflict. The four years of that struggle saw the nations involved manufacture nearly 100,000 planes of all types. The haste with which those planes were constructed, and the status of the art in those times, caused many errors and many crashes to be built into those early war planes. Their own deficiencies and inadequacies, combined with the fact that the military leaders were old and were little disposed to welcome new weapons, prevented the airplane from developing into the stature of a full-fledged weapon of decisive consequence by Armistice time, 1918.

Had the war lasted another six months it is quite likely that the combined British and American bombing effort on German wartime industry would have revealed even to the

Latest U. S. heavy bomber is this Consolidated B-24, which British call the "Liberator." Utilizing new Davis airfoil, tricycle landing gear, the B-24 is faster than B-17's. U. S. has ordered several hundred.



most obtuse the fact that artillery had grown wings, that it was within the power of a military commander to dispatch a winged shot a couple of hundred miles into the enemy country and lay the destructive force of high explosives on munitions-manufacturing establishments, communication centers—the sinews of war. In that event it would have altered current history. Mr. Goering would not have been able to lift the depressed morale of the German people with the thought of a new weapon. The people of France would not have placed complete confidence in the greatest army and a stout wall of concrete and steel as the solutions to defense. The people of Britain would have been able to visualize a decisive battle which did not take place on the sea, with navies the vital factor.

Now that the fate of Europe turns on the Battle of Britain in a death struggle between German bombers and British fighters, now that we are engaged in a belated effort to make good our arrears and produce an air force capable of defense against any that exists anywhere in the world, it is well, it is wise, to examine this new weapon, the military airplane.

The style in fighting planes changes as rapidly as the hat and dress styles in Paris. The pendulum in aircraft design swings faster than a grandfather clock. The superior airplane today may be discarded as unsafe or unsound for air combat tomorrow.

The difficulty with the military airplane lies in the fact that it is always a compromise. How simple that would be, if one airplane type could serve as fighter, bomber, reconnaissance plane and cargo transport. There are some very different and widely varying tasks to be performed by the air weapon. The ultimate in efficiency for each of these tasks requires a different kind of vessel. It is extremely unlikely, therefore, that the all-purpose airplane will be developed soon—one which will serve well all military functions and purposes.

The present trend in all the leading nations shows a breakdown into five different classifications—the fighter, the bomber, the reconnaissance and observation plane, the cargo carrier or transport and the training plane. Each of these may have several subdivisions. In the fighter field we now find the tiny little single-seater, called an interceptor, which is really a flying machine-gun nest carrying one man, a limited number of guns, a small quantity of ammunition, and a tremendous amount of horsepower in the engine. It has one important quality and essential built into its compact little structure and that is the ability to climb rapidly to great altitude, 30,000 feet or more, to engage the oncoming enemy bomber. Speeds for such planes must be more than 350 m.p.h. for present-day combat if the air battles are to be won. [This prediction already has reached the 400 m.p.h. mark.—Ed.]

Then there is the multi-engine fighter, a bigger plane with two powerful engines, carrying a considerable number of machine guns and perhaps 20 mm. or 30 mm. cannon, and generally possessed of longer endurance for flight with consequent increased range. This type of plane is an air destroyer of a sort which cruises around the skies looking for heavy bombers and other worth-while prey. The latest type may carry one or more in its combat crew.

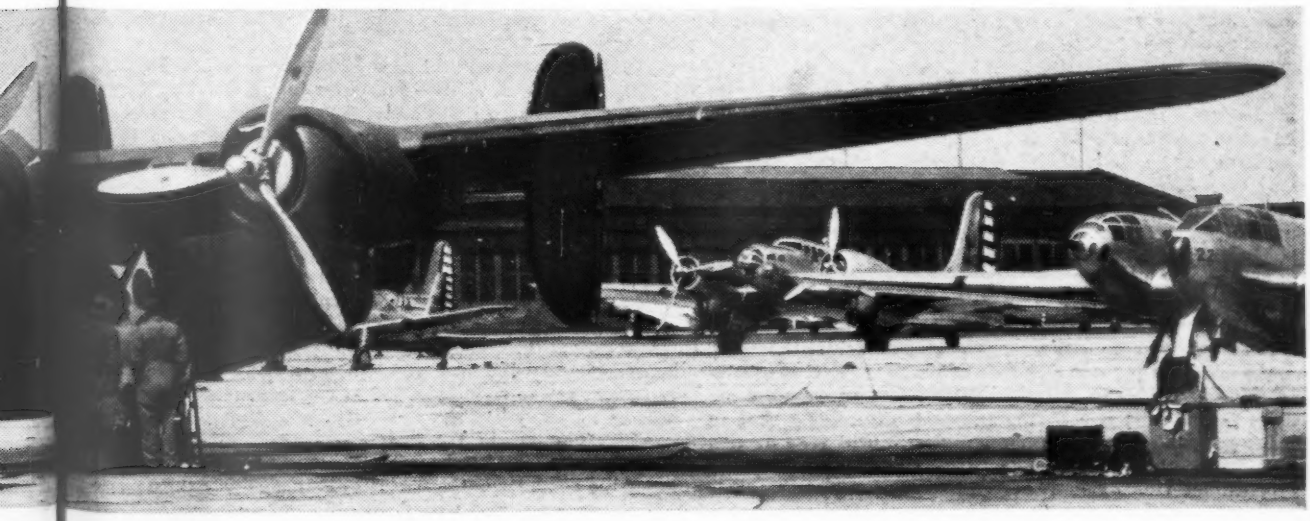
There is a multi-seater fighter prevalent in some air forces, sometimes called an accompanying fighter, with 1,000 to 2,000 mile range, many guns and sometimes heavy cannon, a large supply of ammunition and generally two gunners and perhaps even a navigator, in addition to the pilot. The original conception in the design of this craft was to have a fighter to accompany bombers on long missions into enemy territory to ward off enemy pursuit or fighters. Most of those which have been developed to date have not shown great promise. They have been too slow and not sufficiently maneuverable to serve as the complete antidote to the smaller interceptor fighter.

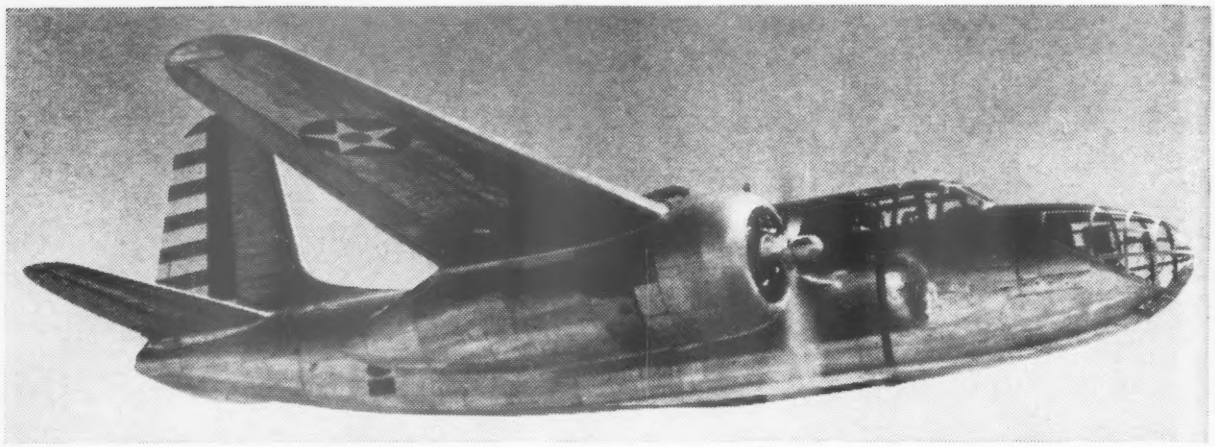
There was a time in this country, and to a lesser extent in the air forces abroad, when many held that the fighter plane had passed from the picture. The events of the past year in the sky battles above Europe have settled all that and have left no chance for argument. The valiant stand of the fighter command of the Royal Air Force in the Battle of Britain showed conclusively that the only reliable antidote to the enemy bomber is the fighter. In modern air combat it is the fighter that really brings disaster to hostile bombers. Other weapons tend to send the hostile planes higher in the air but do not consistently bring them down as do the pursuit or fighter pilots. Now there is a general feeling that 50 to 60 per cent of the well-balanced air force of a nation will consist of the fighter type.

BOMBER

Despite the knowledge that the fighter under certain circumstances may be the superior of the bomber and capable of shooting it down, it is none the less a fact that the bomber is the essential nucleus of an air force. The fighter is a defensive type of aircraft strategically, but the bomber is distinctly offensive in character. Battles and wars are won

Capable of carrying several tons of bombs, B-24 is heavily armed using new power-operated telescopic turrets mounting heavy caliber machine guns. Many "Liberators" are flying Atlantic non-stop.





The light bomber, here exemplified by the Douglas A-20A, is a low-altitude, heavily-gunned airplane designed for attack against personnel and mechanized columns. It carries over a ton of bombs.

by a vigorous offensive and seldom, if ever, by the defensive.

Two things have served to retard the development of the bombing plane in this country. One is the feeling that the bombardment airplane, being a weapon of offense, brought into our war machine a device which operated in a manner contrary to our national military policy, which we have stoutly maintained for more than a century as defensive and mainly for the protection of our own shores. The other reason lay in the fact that the bomber, like a snake in the grass, is a particularly unpleasant fellow. He was unpopular with all and sundry because of his ability to drop high explosives, not always well aimed, at some establishments and peoples heretofore believed safe from molestation in warfare. Some years ago it was even proposed in international negotiations that the bombing plane, like poison gas, be labeled taboo in armed conflict.

Like the fighter, the bomber classification must be broken down into several types—the heavy, or long-range bomber, the medium bomber, and the light bomber—classified, as the names imply, largely according to the size and weight of deadly cargo carried.

The heavy bomber, the most prevalent model of which is four-engined, each giving out 1,000 or more horsepower, and around 40,000 pounds in weight, capable of carrying 4,000 to 8,000 pounds of bombs for about 3,000 miles, is, because of its power and range, the most important of all air force weapons. The ideal heavy bomber for any nation should be able to reach any part of the enemy country where military facilities may be located. If any nation can visualize its prospective enemy, it can tell without fallacy the range required for its bombardment.

The heavy bomber is at once a tremendous and a delicate mechanism. It carries more than 300 instruments, each important to the safety and operation of the craft and the performance of its mission. It carries a normal crew of nine men—a pilot, copilot, navigator, bomber, aerial engineer, radio operator and three machine gunners. Later and heavier models will carry additional machine gunners. As the big bomber can cover a range of 6,000 to 8,000 miles or more, it will require alternate or replacement crews, since combat crews in flight cannot maintain reasonable proficiency for missions longer than six or eight hours.

A factor which influences large bomber design tremendously is the necessity for carrying tons of gasoline. Fuel is usually in wing tanks. This gasoline storage has of late become more complicated due to the necessity of housing fuel in bullet-resistant or self-sealing tankage. Some idea of this problem is conveyed by the fact that a bomber of the latest type carries 11,000 gallons of gasoline. For comparison, it is to be noted that a standard railroad gasoline tank car carries but 8,000 gallons. Extra fuel in drums can be carried inside.

Another influence on design is closely affiliated with the primary mission of the plane. It must nest in its bomb compartment four to 10 2,000-pound bombs, or their equivalent in weight of smaller types. This bomb compartment is more than a woodshed for cordage of logs. There must be a mechanism to permit bombs to be dropped instantly and in the numbers required, one or all as the size and character of the target demand.

Some of the auxiliaries of the heavy bomber are vital, too. A plane of this size must carry an auxiliary power plant in order to lift its great wheels into the wings on the fuselage and out of the air stream for greater speed, in order to provide lighting, power for several radio sets, the starting of engines, the lowering of landing flaps and other similar purposes. The plane must provide a chart room with facilities for celestial observation and complete navigational equipment. A vessel which can travel thousands of miles and fly at great height must be supplied with the direction of excellent navigation.

Affording suitable stations for defensive gunners is no mean problem. One lesson which has come out of the present war is the fact that fighters soon find the blind spots on bombers and invariably work their way into these blind spots for deadly attack. A weapon which costs a quarter of a million dollars or more and takes more than 100,000 man hours to build must be capably defended. There must be blisters, slide openings, turrets or other suitable apertures to permit the gunners aboard the bomber to see and fire at all angles.

The pilot's compartment now looks like a submarine control room. Its walls are surrounded by several hundred instruments, each with an independent duty to perform or message to give. The necessary provision for blind flight and blind landing instruments lends further to the complication of this problem.

There must be provision also for housing radio equipment and a capable operations, maintenance and repair staff. Two or three, and even more, radio sets are often carried on the heavy bomber. This equipment must be carefully shielded from the noise of multiple engines and from the interference of surrounding metal structures.

Lastly, and most important of all, is the provision for the instruments and the men who will deliver the cargo of high explosives at the right time and at the right place. The sole purpose of heavy bombers is for the destruction of important targets. The reason for their existence is nullified unless adequate provision be aboard for aiming and dropping accurately the bomb load. Great secrecy shrouds this compartment and its contents, and well it should. For here in the tight

Latest Air Forces medium bomber is the Martin B-26. Powered by two 1,850 h.p. engines, this ship is faster than most pursuits. It was the first design to be contracted for "off the boards" without tests.

little room resides the delicate trigger to the air weapon.

RECONNAISSANCE AND OBSERVATION PLANES

The reconnaissance plane is the observation plane grown to man size. The observation plane, long and rightly called the eyes of the Army, is designed to do a specific job—to furnish intelligence of the enemy, his strength, his locations, his movements, his dispositions. The observation plane is the type furnished to division, corps and army commanders, of a range of 200 to 300 miles, which can reach any part of the army theater or the corps and division areas. It carries a pilot and observer who does part-time duty as gunner, and some types carry a third man, a photographer, who also substitutes as occasion requires as a tunnel gunner. He is the man who fires the guns which protect from attack from the rear and below.

The observation plane cannot and should not be dismissed lightly, because it is of tremendous importance to the military ground commander. It permits him to see over yonder hill, which the military leaders of old always longed to do. It gives him photographs and maps and carries messages promptly to all parts of his command.

Because the observation plane needs to cover only the limited area of army, corps or division, it is not of necessity a very large airplane. There is a tendency now to break the observation plane into two types, each requiring a different airplane. At first it was thought that one would do. The presence of enemy pursuit in the area where the observation plane must operate makes it necessary for a proper plane of this type to have great speed. This requires a big engine and, consequently, a larger airplane.

The campaign in Poland indicated a special use for a light, small plane, called a command plane, capable of landing in small fields or limited areas where it could carry staff officers between front-line units and permit the commander to look down on a battle scene. A slow plane permitted better observation, it was found, and also gave that short landing characteristic required. The command plane now is fairly well established, therefore, and will require a special plane type.

The reconnaissance plane exists for the purpose of searching over wide areas of land and sea. To be effective, therefore, it must have many hours and many miles of range. This necessitates a larger plane. The present tendency is to use a medium or light, or even heavy bomber and it appears thus far that such planes will be adequate and eliminate the necessity for building a special type for reconnaissance. The substitution of fuel tankage for bomb load will give the added range which is an inherent requisite in a plane which must scour the sea lanes for long hours in search for the approach of the hostile invader.

The reconnaissance plane must carry a pilot and copilot, a navigator, a radio operator and an especially skilled observer. The multiple crew also indicates a larger plane. Upon the success of the reconnaissance mission and the promptness and accuracy of its reports depends the initial dispatch of the bomber, thus furthering the air force objective in the destruction of the enemy target.

THE CARGO CARRIER OR TRANSPORT

Fortunately, the requirements in the cargo plane are not unlike the civil air transport. This plane in its military application has a variety of uses which necessitate some change, for the most part in the seating arrangement or cargo compartments, over the normal civil transport. The military cargo plane must be equipped for conversion as an ambulance plane. There must be attachments in the passenger cabin for litters so that wounded men can lie horizontally and be treated while in flight.

Some planes of this type will be freight carriers. Others will be equipped as troop carriers and for the dispatch of parachute troops. The operations in Norway and in the Low Countries [and, recently, in Crete.—Ed.] indicated a new importance and stressed a new emphasis on provision for parachute troops and air infantry. It is uneconomical to use bombers for this purpose and they are not designed and equipped to do the job as effectually as can transports or troop carriers.

While the civil transport plane with slight or no interior modification can be pressed into service as a military troop and freight transport, it is not wise to rely exclusively on these planes to augment the air force. They will not be present in sufficient numbers, for one thing, and they will be busily engaged in the transport of mail, freight and passengers, which will be an equally or more important function in wartime than in peacetime. The balanced air force will always, therefore, possess a large fleet of cargo and transport planes.

A problem which has not thus far arisen, but which may in the future air war take on great importance, is the armament which these freighter troop carriers must have. In the operations thus far they have carried little or no armament, and have relied upon operations over enemy country in the hours of darkness and the fact that much of their flying is done over their own territory where they come under the protection of friendly pursuit. The war of the future, involving intercontinental transport as against international transport on one continent, points toward a new factor, and that is the necessity for providing protective armor and armament for this type.

There is an important advantage in the Army developing

Army air transport squadrons are using this type Douglas C-39 cargo-plane. Bigger ones already are on order.

Standard Army observation type plane is this North American O-47A with camera in bottom of fuselage.

its own cargo planes. It is important to any air force to simplify its supply problems by having as few types as possible in all this auxiliary and adjunct equipment. The radio equipment would thus be of a type which can work Army stations and the pilots and mechanics are more likely to be familiar with the engines and instruments both in operation and maintenance, if these are all of standard military type.

The Army Air Forces now is using two standard transport types, a C-33 Douglas, similar to the commercial DC-3, and a C-45 Beechcraft, a light, twin-engine transport capable of carrying two pilots and six passengers. Both of these types do, however, use Government-furnished equipment in the accessory items such as propellers, engines, radio and instruments.

It is not unlikely that a new cargo type, the heavy freight carrier, will shortly appear in the military air arms of the leading nations. There is some evidence of it abroad and there is a general demand among the tactical units and in the supply agencies for such a type in this country.

The general use by the German air force of aircraft as a principal supply agency in recent campaigns, particularly in Norway and in the Netherlands and to a limited extent in Poland, started the military leaders seriously considering this problem. [German transports since have been used with great success in Greece, Africa and Crete.—Ed.] Such a plane would be a freight carrier. The designs submitted to date point to a fairly slow plane with great weight-lifting ability and particularly designed for the rapid loading and unloading of freight. A plane is visualized which would permit forward loading from ramps, of ambulances, staff cars and even tanks as regular cargo. Such a plane would also serve admirably as a troop carrier, since 30 to 50 men with their individual equipment could be accommodated in roomy but unfinished cabins without seats.

There has been some discussion and some experimentation in the employment of gliders in tandem trains to be towed behind aircraft, much as a railroad engine draws a string of boxcars, for use in freight and even in personnel transport. [This prediction, originally almost a year old, has been made a reality by the Germans in Crete.—Ed.] Several advantages have been pointed out for the use of gliders in this way. The first is economy. Without the necessity for engines, propellers, instruments, radio and many other expensive accessories, such gliders would be economical to construct and could be built in quantity at great speed.

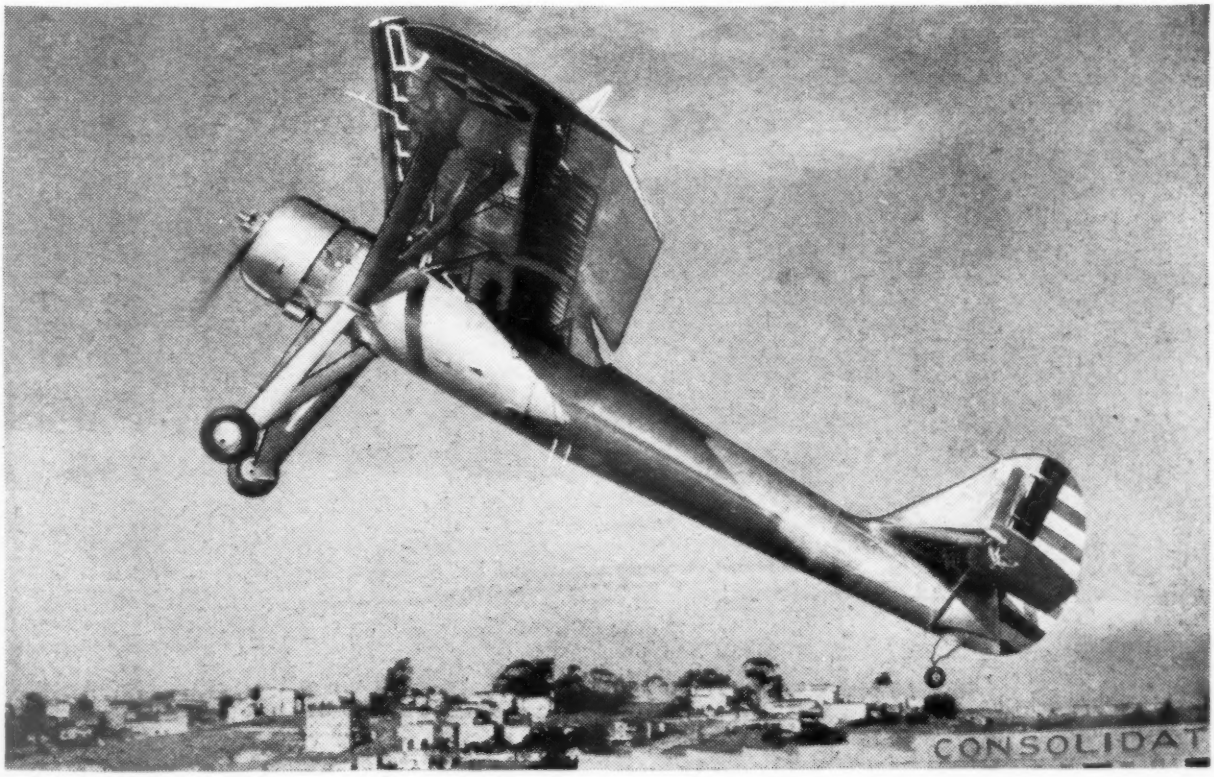
A second advantage of the glider train lies in the fact that it could be towed over the enemy country during the hours of darkness at high altitude, the individual glider being cut loose and piloted to predesignated airdromes without alarm. The German air force demonstrated in Holland the great importance of early occupation of enemy airdromes with sufficient troops to hold those airdromes until reinforcements can arrive either by land or air. It is possible for a nation fighting a contiguous enemy completely to demobilize the opposing air force if it could occupy all airdromes simultaneously and without warning.

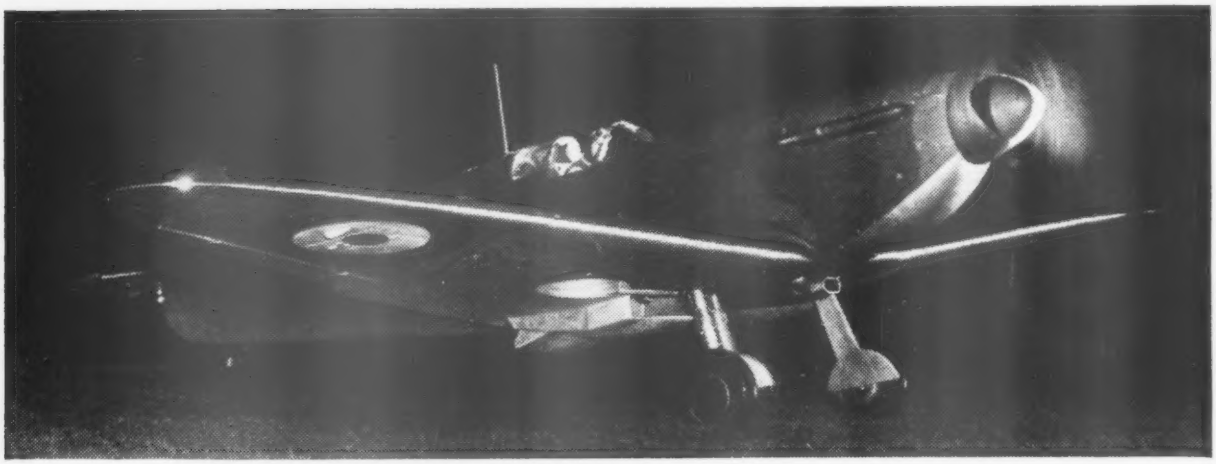
Designs of this giant glider have already been completed with sufficient size and carrying capacity to carry light tanks. One particularly forward-looking inventor used the tank as the motive power, to give the glider speed enough on the ground to take the air, thus to assist the towing airplane in the take-off.

The use of the glider for transport and the employment of the glider train is something for the future, but an innovation undoubtedly worthy of serious study.

Any nation in building an air force cannot think of its fighting planes alone. This air transport service for troops, supplies, ambulances and medical service and for the trans-

A new category now coming into use in Army observation and reconnaissance is that of the slow-flying liaison plane. First type to be accepted in this group was the Ryan YO-51, now undergoing field tests.





Performance of British "Spitfire" against German bombers and fighters has remodeled U. S. pursuit aviation. In-line motors, armor, added armament used by British are being put on U. S. warplanes.

port of artillery and heavy equipment, is a necessary adjunct to the maintenance of any efficient fighting force in the field. The speed and range of modern air forces makes it imperative that they be self-sustaining. The speed of modern mechanized forces makes it distinctly advisable that at least a portion of their supply columns and agencies travel through the air.

There is a great danger, in times of economy and of relative international calm, in stripping military organizations of all save priority items. It will not be surprising, therefore, if the time comes when it seems advisable for those in authority to reduce the size of our flying fighting forces, that the transport plane will be the first to suffer. This is a danger which must be avoided. It is as true now as in the time of Napoleon, as the old master of military tactics and strategy said, that "an army travels on its stomach." The air arm is no exception to this rule. It will never be more efficient than its maintenance and supply agencies. The cargo plane, therefore, must always be considered as an integral and important part of any well-rounded and completely developed air force.

TRAINING PLANES

From 55 to 60 per cent of the aviation strength of a modern air army is comprised of training planes. Under our own program, as the War Department has announced, for the procurement of 14,000 planes by April of 1942, roughly 6,000 of these will be of combat types and 8,000 training planes. [Since this was written, the quota has been raised to 50,000 planes.—Ed.]

Because the training plane does not perform a combat mission and since it tends to be a small, light plane more easily capable of rapid manufacture and mass production, it is all too frequently overlooked in laying plans for air force building. Since the personnel side of an air force is of equal importance to the matériel side and, since the training plane is the instrument for providing pilot personnel, it follows that the training plane is a *sine qua non* to the large and powerful air army.

There has been a feeling in some quarters of late, and particularly here in our own country, that the training plane did not need to be a distinct military type, since light commercial and sport planes would serve adequately and were already available in sufficient quantity to take care of the training need. There are several reasons why this is fallacious thinking. It is highly desirable, in order to have uniformity in training methods and a common standard for the pilot output, that all training planes for a given stage in training be of a common type. Also, this greatly simplifies the problem of maintenance, overhaul and repair, as is perfectly understandable. If, at one of our large primary flying schools, employing 100 planes, there were eight or 10 plane types, the supply problem, the spare parts problem and the mechanic training problem would be tremendous.

The same careful planning and intelligent designing must be put into training plane production as is required for fighting aircraft, if maximum efficiency and competence is to be the rule. In our Army Air Forces three principal training plane types have been found to be necessary. The first of these is the primary trainer, the second the advanced trainer and the third the bimotored trainer.

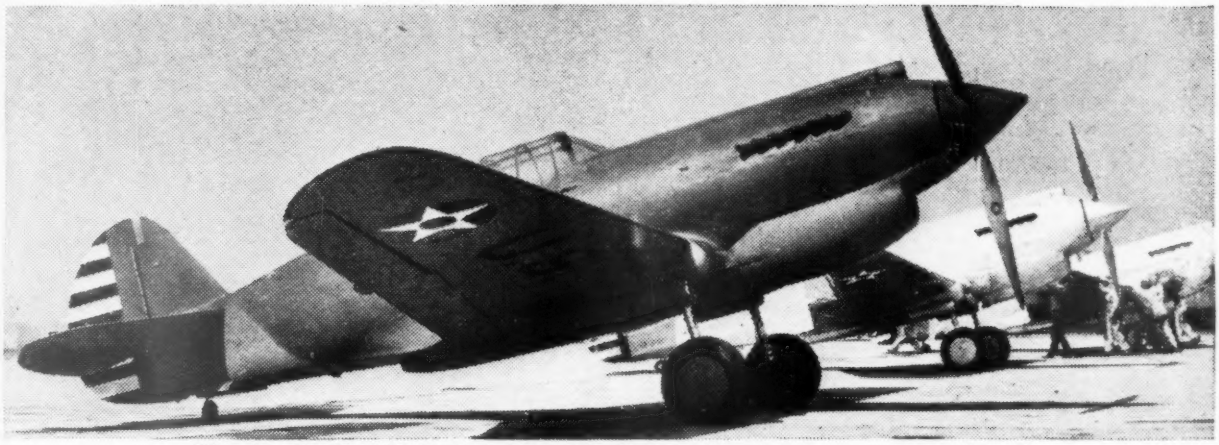
The primary trainer is a fairly simple, light two-seater of about 2,000 pounds in weight, and powered by a 100 or 125 h.p. engine. It must be rugged and sturdy and must give excellent vision for both instructor and student and provide for their visual intercommunication. Much experimentation on tandem, as against side by side pilot arrangement, indicates the definite advantage in the present tandem seating arrangement in standard Army training planes.

Since students begin on the primary trainer, it is wise to have a plane with slow landing characteristics and with no tricks such as ground-looping tendencies after landing. A rugged undercarriage is an understandable essential. The instrument panels can be simplified to the barest minimum. A few engine instruments, an altimeter and an air-speed indicator, generally comprise this limited group.

The advanced trainer is necessary because it is too long a leap from the 125 h.p. primary trainer to the 1,000 h.p. or more, service type airplane. The advanced trainer is somewhat larger than the primary trainer and about double the horsepower—250 to 300 h.p. The advanced trainer will generally also have a cockpit closely resembling the service type plane. It has a complete instrument panel, flaps to retard landing speed, adjustable pitch propeller—in fact, all or nearly all of the duties required of the pilot in the service type plane will be represented.

Since a great majority of all service type planes now are low-wing monoplanes, it follows that the advanced trainer is of that design. A conscious effort is made to provide flying characteristics closely resembling those of the combat types. Being a smaller, lighter plane, however, than the majority of the combat type, it does have a somewhat slower landing characteristic which is advisable for the student who is still in the intermediate pilot-training stage.

The twin-engine trainer has but lately come to join the training plane group. The necessity for it is incident to requirements for economy and to afford training to the pilot personnel in multi-engine operation. It will be a reasonably light, low-wing monoplane with two engines of 300 to 400 h.p. each and with an instrument panel closely resembling the service type, medium, twin-engine bombers. Until recent



Although similar to British "Spitfire" this P-40 has longer range, but fewer guns. New models will be heavier armed with heavy caliber guns. Speed is over 370 m.p.h. at altitudes above 20,000 ft.

times, it was a practice in our Army Air Forces to use obsolescent bombardment type planes for this training. Since these are powered with two engines of at least 1,000 h.p. and since they are large and expensive airplanes, any mass pilot-production scheme develops the inherent weakness in this system and indicates the necessity for a light, twin-engine trainer. This new type appeared concurrently with the Army Air Forces expansion program—1939 to 1941—and is here to stay.

FOREIGN PLANES

In considering our own airplane types, the question is naturally raised as to how they compare with foreign planes as to types, characteristics, and performance. Generally speaking, air experience which dictated several types in our own Air Forces had done the same thing to foreign air forces, and all agree as to the necessity for five general types—fighter, bomber, reconnaissance, cargo and training.

In England the famous *Spitfire,* a single-seater, single-engine fighter which now is in the headlines as bearing the brunt in the Battle of Britain, is the English counterpart of our single-seater fighter. Its performance and characteristics are not unlike one of our own standard fighters, the Curtiss P-40.

In Germany the headlined Messerschmitt single-seater, single-engine fighter possesses characteristics and utility of the standard English and American fighter. These three fighters are similiar in appearance, and are each powered with engines of between 1,000 and 1,150 h.p. There are some variants such as fire power, instrument panels, radios and accessory equipment, but for the most part a comparison of these three fighting planes shows that in each country the ultimate has been built into the fighter insofar as lay within the power of the engineering genius of the nation concerned. The remarkable similarity is indicative of the fact that no nation has as yet been able to scoop the field in airplane design. The British light bomber is a twin-engine, low-wing monoplane with characteristics, bomb-carrying capacity and range consistent with the purpose and missions of a light bomber. They carry two pilots, a bomber and two gunners, and are equipped with radio, navigation aids and instruments, to permit their operation day and night in all kinds of weather. Except for a somewhat slower speed, they do not differ greatly from our A-20A, or standard light bomber.

The German air force's bomber types are low-wing monoplanes, powered by two engines of more than 1,000 h.p. each and carrying a normal crew of five. They carry fuel to give a range of about 1,000 miles and a bomb load of roughly 2,000 pounds. In speed they are slightly slower than our standard bombers.

In both England and Germany other types, not strictly bombers, are pressed into use as light bombers. In Germany

This Messerschmitt Me-110 is current twin-engined interceptor used by Germans. It carries two heavy cannon and several machine guns. Because of lack of fast bombers it is sometimes used for bombing.

the Messerschmitt Me-110, which is really a twin-engine fighter, often carries a bomb load.

In the heavy bombardment field neither the British nor the Germans have as yet produced, in quantity, four-engine, long-range bombers. It has been variously reported that both countries feel that the failure to follow our example in the production of a long-range, four-engine bomber was a shortsighted mistake and they now are working frantically to make good their arrears and may soon have in production planes similar in size, performance, characteristics and range to our *Flying Fortresses*. The lack of such planes has made it impossible for either of the principal combatants in the European air wars today to reach freely all parts of the opposing countries with the devastations of air bombardment.

In midsummer of 1939 when the Army Air Forces' first expansion program was launched, there had not been sufficient air fighting abroad to demonstrate completely the desirable and essential characteristics in each plane type. Speed, range, armament and many other factors were based upon theoretical considerations. By midsummer of 1940 it had become apparent that certain plane types were outstanding in the air fighting abroad, while others quickly passed from the battle scene. There was intelligent inquiry to determine the reason for these striking successes and outstanding failures. This inquiry showed that the air fighting in Poland, Norway, Holland, Belgium and France had demonstrated the necessity for limited personnel armor, for bulletproof or self-sealing fuel tanks and for additional and, in some cases, heavier armament and a better disposition aboard planes for defensive guns. Army Air Forces experts were dispatched to the European battle fronts to secure the latest information on combat developments. Immediately the information was received in the United States, the Army Air Corps issued change orders on existing contracts in order to incorporate all necessary improvements. Trained observers continuously are being sent abroad to follow closely the air operations and watch the kaleidoscopic pattern of changing plane types. By rotating these experts, we are able to have available knowledge of the latest developments.

It is a matter of relief to our military leaders and it must be a matter of pride to all our citizens to know that as we stand today our planes, type for type, are in all cases equal to and in many cases superior to the aircraft now engaged in the bitter fighting overseas.

Chapter Two

WINGED WARRIORS

"The gratitude of every home in our island, in our Empire, and indeed throughout the world, except in the abodes of the guilty, goes out to the British airmen who, undaunted by odds, unwearied in their constant challenge and mortal danger, are turning the tide of world war by their prowess and by their devotion. Never in the field of human conflict was so much owed by so many to so few."

—Winston Churchill

THE first flight piloted by a military man in the United States was made by Lieutenant, now Colonel, Frederick E. Humphries. The second such flight, made but a few minutes later, was accomplished by Lieutenant, now Colonel, Frank P. Lahm. That was in 1909. Both Colonel Humphries and Colonel Lahm made their initial flights at College Park, Md., after a brief course of training under the supervision and tutelage of the Wright brothers. Thus military airmen, our winged warriors, began.

Remembering that there now are more than a quarter of a million pilots in the world and considering the number and size of aircraft available in all the nations today, it is remarkable that the first man who ever flew still lives and that the United States Army officers who accomplished the first military flights yet survive.

The fathers of flight were not military men, but many of their early students during the first five years were from the military establishment. It was not long before the general realization that the airplane was a new war weapon caused army officers here and abroad to flock to the pilot ranks. The fact that two major and several lesser wars have occurred during this 31 year span has further served to lend to aircraft pilotage a distinct military tinge. In our Army, with but few exceptions, the pilots have been officers and that, until quite recently, has been the general vogue in the other armies of the world. The pilot generally has been looked upon as a professional because of the long period of training required and because of the basic educational and mental requirements.

In August, 1914, when the first World War began, there were about 1,000 trained flyers in the entire world. Four years later the military schools of the combatant nations had turned out more than 100,000. More than 95 per cent of the airplanes in existence in 1918 were military planes. At the close of that struggle, as the armies of the world were disbanded, the larger proportion of these trained military flying men went back to civil pursuits—but took this flying training, their pilot careers, back with them. These were the men who initiated civil aviation, who became the first airmail and airline pilots. These were the air gypsies who carried aviation to the countryside. They and their ex-Army training planes visited every hamlet and town in the country, making demonstration flights and carrying passengers. The military flying man, therefore, has left an indelible mark on the history of aviation in this country. For a long period of years, with few exceptions, the flight records, speed, altitude and endurance, the world's air marks, were established by these men.

It is possible now to determine fairly well the basic essentials of the flying man, his predominant characteristics, the psychological and physiological requirements—in short, the type of human being required for a military flyer. In the genesis of aviation the theory grew up that the flyer was a daredevil, a happy-go-lucky, devil-may-care type of individual. Even during the last World War he was looked upon as possessing more courage than wisdom, more daring than caution, more rashness than stability. Today's war pilots, however, are serious and very sober young men who recognize the importance of their jobs.

The individual selected for student pilot by our Army Air Forces must measure up to exacting standards. He must be between 20 and 27 years of age. He must possess perfect physique with a special emphasis on complete normality in eyes, heart, lungs and neuro-muscular co-ordination. He must have had a college education or at least a minimum of two years' training in a recognized college or university. When our 135,000,000 Americans are shaken through this fine meshed screen, perhaps less than a million qualify. Only about 60 per cent of those who begin training demonstrate a capacity to assimilate the required degree of proficiency in aircraft pilotage.

It is possible, therefore, for a nation such as ours to have a total of not more than 500,000 first-class military pilots. At that we are more fortunate than the other nations of the world because the American boy has a mechanical background. He has driven an automobile and handled many other mechanical or electrical appliances. He has a facility and adaptability for the plane and the engine and its myriad instruments which is not normal for other nationals. From the standpoint of man power alone, therefore, the United States as we stand today, has the raw pilot material for the largest and the most superb air force in the world.

The present training program of the Army Air Forces provides an annual production of 12,000 pilots per year. In event of war, with that added incentive and under pressure we should be able to speed our pilot rate to 50,000 military flyers every 12 months.

For many years the Army Air Forces has been ably assisted

in its pilot procurement programs by a highly trained group of specialists called flight surgeons. These men have worked unceasingly for more than 20 years to determine and define the pilot type. They have been assisted in this work by modern medical organizations and several of the larger educational institutions. Stripped of all its verbiage and high-sounding scientific terms, the type of boy most likely to succeed as a military flyer is the normal, athletic, American college youth and our flight surgeons have developed a remarkable facility at picking the type after a brief interview and examination.

Many of our old flying instructors had a rough and ready system of their own. More than one has said he could observe a boy playing a game of tennis or driving a broken-down Ford, and tell whether he could be taught to fly. This was a crude way of saying that the flying type is a non-awkward youth who co-ordinates naturally, who has excellent and complete control over his muscular reactions as against one whose movements are awkward or studied and calculated. It was believed for a long time that a high-strung, nervous type of boy made the best flyer, certainly the best pilot of the single-seater pursuit plane. The more stolid, plugging type was not looked upon with favor. After years of sorting and sifting it has been found, however, that the latter, while not having the quick agility and facility for the high speed, single-seater, may make the ideal big ship or bomber flyer.

Despite the intricate mechanisms which have been evolved and used by the flight surgeons, the psychological, neuro-psychic and physiological examinations requiring several hours to complete, it is not possible at this time to label definitely and certainly the flying type. This is evidenced by the fact that for the last five-year period in our Army schools, there has been scarcely a change in the curve—between 49 per cent and 40 per cent of each class passing through our schools have been eliminated for failure to meet our standards. This does not mean that some of the others could not be taught to fly. It does mean that they could not be taught to fly sufficiently well to make them safe and economical military flyers.

For a long time the term "flyer" was applied to the pilot only. Of late it generally has been recognized that all members of the combat crew in military aircraft must be classed as military flyers. The pilot's duties, the take-off, the management, direction of the vessel in flight and the return of it safely to earth, have remained little changed. The duties and functions of the other members of the combat crew—the engineer, the navigator, the gunner, the bombardier, the radio technician—have grown steadily year after year with the advent of new equipment requiring an ever-increasing dependence, for successful flight missions, on a multiple crew of superior individuals trained in perfect team play and co-ordination.

THE COMBAT CREW

THE PILOT

There are three rated types of pilots in the U. S. Army Air Forces—the command pilot, the senior pilot and the pilot. The command pilot must have had 3,000 hours in the air and a minimum of 15 years of flying service. The senior pilot must have had 2,000 hours of flying and a minimum of 10 years' total flying service. The large mass of our pilots, with a flight time and length of service below these minimum requirements, are classified as pilot only. The flying cadet prior to graduation and the bestowal of the initial rating of pilot is, of course, a student pilot.

The adoption by the Army's flying branch of these pilot ratings is founded on a definite theory. That is that mastery of aircraft pilotage requires, in addition to a year's period of training, the supplement of actual air experience. It has long been recognized that although the flying cadet graduate may demonstrate a state of excellence in the handling of aircraft controls in landing, take-off and acrobatic maneuvers, he still has a long way to go, a lot to learn before he reaches his peak as a military airman. This additional instruction cannot be gained from books or from instructors. It is obtained only by long hours in the air.

Flying ability of the finished type, we feel, necessitates a mastery in equal parts of flying skill and flying experience. It is a matter of some concern that it is no longer possible for the present-day flyers to learn by the cut-and-try methods of the early military pilot. It was not uncommon for a pilot of 1916, 1917 and even as late as 1925 and 1926, to have a forced landing due to faulty engine, effect a safe landing in a meadow or cornfield, repair his damage, let down a few fences and take off and return to his home airdrome. The speed of present-day aircraft is not conducive to forced landings on unprepared fields. The fast fighter and the heavy bomber can be flown safely only from prepared fields. The cost of the present-day airplane makes it impossible to stand the expense of the old trial and error method, where the pilot was both a mechanic, an engineer, navigator, radio operator and a maintenance man. Lack of facilities and skilled mechanicians required the old-timer to repair and check his own equipment for flight.

Although the present-day flyer has lost some of these old-time advantages and experiences, he has gained in some other important regards. His cockpit houses from 100 to 300 instruments as against the eight or 10 on the instrument board of the pre-World War flyer. It requires almost constant study to maintain proficiency not alone in aircraft pilotage, but in the operation of these instruments and in acquiring the co-ordinated story that they have to tell. In addition, there is the oxygen equipment for high-altitude flying, the automatic pilot controls, the blind-flying instruments, the blind-landing equipment, the artificial horizons, the flares and other night-flying equipment, the controls for the operation of flaps and for the raising and lowering of landing gears, the controls for changing the pitch on propellers, the de-icers, the carburetor heaters.

This multiplicity of instruments and installations has added a significant complication to aircraft pilotage. The old-time flyer had little to do but to keep his feet on the rudder, one hand on the control stick and the other on the throttle. His eyes, except for occasional glances at the sparsely occupied instrument board, were free to roam the skies or to observe landing areas. His consciousness could be directed to the feel of the aircraft in take-off and landing. That, however, was not all he had to do. He took off with a prayer, for he had a 50 per cent chance of engine failure on each flight. The annual toll taken by the grim reaper was about 33 1/3 per cent of all those who stepped in a plane. He had to fly his machine, for stability in the air was an unknown quality for a plane. Now there are numerous other distractions and the operation of a much more complicated equipment. Scientific developments have given us many more reasons for the requirement for long and thorough pilot training until we subconsciously read and take cognizance of our instruments. Undoubtedly divided attention has caused more than one accident and cost more than one pilot his life. There is reason to believe that more than one pilot has pulled the wrong lever and lowered a flap when he intended to lower a landing gear, with a consequent and succeeding crash. The famous Sir Kingsford Smith, who disappeared on one of his transcontinental journeys, and whose fate has never yet been discovered, told us in writing about his flight from Australia to New Zealand in a storm at night, that he was suddenly confronted with his air speed having dropped from 150 to less than 90 m.p.h. This ship, he said, felt as though it was staggering through the air. It was several minutes before he discovered that instead of pushing the button to change the pitch of his propeller, he had pushed the button which dropped his flaps.

The pilot is a senior combat crew member. The ship during flight is under his control and direction. It is his responsibility that it accomplish its mission and return safely to its home airdrome. The pilot in multi-engine craft is assisted by a copilot and by the other trained members of the combat crew.

It will be an unfortunate day for national defense and, therefore, for the safety of our country, if we ever permit the pilot standard to be lowered. If we relax the requirements, if we ever treat the pilot as other than professional, if we ever require of him any but the highest standards of performance and efficiency. There is no military man outside the realms of command upon whom military requirements place a heavier load and a greater responsibility.

Consider the brief span in the life of a Royal Air Force pilot in a *Spitfire* above England. He is on alert; he sits parachuted, helmeted, hunched in the tight little seat of a single-seater fighter. The siren blasts. Crackling through his earphones comes the command to take off, followed by the altitude and direction of the German bombers sighted over Dover.

He taxies hastily to the runway, "pours coal" to full throttle and sticks his nose toward the overcast at maximum climbing angle. He takes a straight climb through the clouds on a course toward the coast. At 6,000 feet he breaks through. Now he is in bright sunlight, but there is little time to reflect on the beauty of the white carpet below. He must adjust carburetor temperature and wipe frost from windshield and gun sight. The bombers were reported at 25,000 feet so he still holds the nose up, adjusts fuel mixture, pulls back on the charging handle to arm his guns—two, four, six minutes; six, 12, 18,000 feet. Over there is the channel, but where are the bombers?

There to the right, antiaircraft puffs may show dimly in the sunlight—telltale indication to the enemy position. Then there is a glint of sunlight on a metal wing where the rain has worn off a patch of paint. The boy in the *Spitfire* heads for the formation, singles out the left rear bomber, moves in behind, opens up at 100 yards with all his guns. In an instant he pulls up to avoid collision. As he turns to look down at his prey, to go back for the next one, he smells petrol, there is a break in the deep-throated roar of his engine, now he can see his propeller. He knows the grim answer. As he flew over the enemy bomber, a bullet cut a gas line.

Below there is no land in sight. Water—miles of it—spreading below. It must be under the cloud bank to the west. He starts a flat glide toward shore, stretching it for land. At 3,000 feet it is quite evident he cannot make it. The *Spitfire* is too fast to set down in a rough sea safely, so he pulls back on the stick, rolls the plane on its back and tumbles head over heels through space. A pull on his parachute rip cord and he sits beneath a huge, white canopy. He sees his stout little plane hit the water with a great splash and is glad that he is not aboard. The next splash is his own.

As he tastes salt water and desperately fights his way from under the wet folds of his 'chute, he may reflect that life, and death, move swiftly in this air business. The hour hand on that broken clock in his *Spitfire* has made but half a journey since he sat warm and safe in his home airdrome.

THE BOMBARDIER

The bombardier is an indispensable combat crew member on all types of bombardment aircraft, light, medium and heavy. He is intimately connected with the sole purpose of the existence of bombardment aircraft, viz., the laying of high explosives with accuracy on important targets, vital enemy objectives. War has demonstrated time and time again that bombers who cannot hit their targets are of little more than a nuisance value in war. Bombing units must be able not only to find a target, but they must be able to hit it.

In the past this combat crew member, like the pilot, has been an officer with the educational requirements, the pay and emoluments and the increased rank, with age and experience, on the same terms with the pilot. Of late there is a tendency to use an increasing number of enlisted men as bombardiers. Early trials indicate that especially selected enlisted men, possessing the requisite education, can be trained to function admirably as bombardiers. It is not unlikely that a proportion of bombardiers will always be officers—at least one, the master bombardier, in each flight, generally in the flight leader's plane. The duties of this flying team member require a precise skill in the operation of delicate instruments and a facility at rapid mathematical calculation.

Physically and psychologically, the bombardier must be of the same stern stuff as the other combat crew members. It is probable that it is wise and well for him to be the most phlegmatic of the flying brotherhood. He generally has his back to the fight. It requires a stiff spine, knowing that a fighter is on the bomber's tail pouring bullets into it, to sit with eyes glued to instruments, with back to the fray and observe the steady progress, the ticking of the second hand and the approach of the target, all the while being unmindful of the missiles of death crashing through the plane structure around him. The gunner faces the attacker; he has an outlet for his emotions in the trigger he can pull and the fire he can return. The pilots in the bombing plane also have their backs to the attack, but they have controls in their hands; a little outlet for emotion is provided in a steadying, continuing job to do. The bombardier sits and waits. On the return from the bombing mission, after the accomplishment of the attack, after he has released his "eggs," the bombardier may take up machine guns and serve as forward or tunnel gunner, but as the target approaches it is not his to observe or participate in the air battle. The target below and his means of effecting it must have his undivided attention.

In our Air Forces, we are offering training as bombardiers to the flying cadets who are eliminated from the pilot school. A considerable number of those who have failed to demonstrate a capacity to absorb pilot instruction are taking advantage of this opportunity to join the Air Forces as a combat crew member. It is a new scheme and seems to be working out well. These men will be commissioned reserve officers upon graduation from the bombardier course and, upon completion of training, will serve as the master bombardiers in the bombing formations.

AERIAL ENGINEER

The early pilots were their own engineers. There was not room in their frail craft for an engineering specialist. Moreover, the engines were not of a type to permit treatment of their ailments and whimsies while in flight. The advent of the larger airplane, the multi-engine, heavy bomber, brought the aerial engineer into his own as an essential combat crew member.

In our Army Air Forces the aerial engineer is generally an enlisted mechanic of seniority and long experience. Some of them on duty with the larger planes, at least one per squadron, will be officer graduates of engineering schools. The larger airplanes of 60,000 pounds or more, which are now coming into use, have engine locations and dispositions so that considerable maintenance work and repair can be accomplished in flight. Airplanes of the *Flying Fortress* type have more than 100 engine instruments, all of which must be scanned frequently. Each of the four engines has 12 to 15 controls and adjustments which can be accomplished in flight. The aerial engineer, even on the longest flight, is continually busy and occupied with essential duties important to the successful accomplishment of the mission. In landing and take-off the aerial engineer has important responsibilities and often substitutes for or helps the copilot in operation of flaps, raising and lowering landing gears and many other mechanical adjustments.

Enlisted aerial engineers are selected from the ground maintenance crews. Outstanding men are given this as reward, for the old air soldier generally loves to fly and undertakes eagerly this combat crew assignment.

NAVIGATOR

Of necessity, the early pilots were their own navigators. In those days of extremely short flights there was no use for celestial navigation and little for dead reckoning, for the "iron compass"—as the airman called the railroad—and other telltale landmarks guided the flyer. With full loads of gasoline the planes could fly little farther than the pilot could see on a clear day. Now, when military airplanes in com-

mon use can fly across the continent without landing, and often travel in the substratosphere, the navigator is one of the most important members of the combat crew.

One of the outstanding lessons from the current wars is the fact that it is highly important for the bombardment airplane to take cover in clouds and darkness and the navigator assumes an additional importance. For a long time it was believed that instruments could not be developed which would permit of accurate celestial navigation for aircraft. This belief has now been completely disproved. Trained and experienced aerial navigators can give the plane's position within an area of three miles, even though traveling at speeds in excess of 200 m.p.h.

The proficiency which an alert and highly skilled aerial navigator can obtain from reading the heavenly bodies was demonstrated by Harold Gatty on his flight around the world in the *Winnie Mae* with Wiley Post. Upon their return Wiley told an almost unbelievable story of a landing in far Siberia. He had been flying for hours above one layer of clouds and beneath a high overcast. Gatty had been furnishing bearings by dead reckoning. They had reached a point near midnight when, by the dead reckoning calculations, they felt their landing point was approaching. Post signaled Gatty for a location of the landing field hidden by the solid clouds below. Gatty said, "Climb through the overcast and give me a few minutes to shoot the stars and I will tell you where you are." Wiley stuck the nose of the ship skyward and climbed through at 18,000 feet into a crisp, starlit Siberian night. Within a very few minutes Gatty gave the course, a rate of descent and a time interval which Post promptly put into execution, as was his stoical, methodical habit. The altimeter clicked off the descent—15,000, 10,000, 5,000. Post knew the elevation of the landing area and began to grow restless and show some concern, but at 2,000 feet Gatty's voice came through, "One minute on this heading at 110 m.p.h., make a turn to the left and land." Post says it was pitch dark and raining hard. There was nothing for him to do but trust to his navigator. He followed directions implicitly and when the altimeter as reset showed a reading of 100 feet, pancaked in. Shortly after he touched the ground he realized he was in mud. Eventually the plane nosed up gently. The only damage was a bent propeller. He was on the field he had headed for, but he had slightly overrun one end of it. He had missed by less than a mile an airdrome which he flew 2,000 miles to reach, and had landed upon it blind without ground instrument aid!

That is aerial navigation as the masters can do it. Very few of our navigators will master the art with such perfection as Harold Gatty and Commander Weems, but both these teachers tell us that our students upon graduation from our courses, with a reasonable experience, will be able capably to take care of this essential to long-range bombardment and reconnaissance.

RADIO OPERATOR

Communications always has been one of the primary factors in military successes. The general whose communications have broken down generally has lost the battle. Communications are more important in air warfare than in military operations on the ground. This is due largely to two factors: one, the tremendous speed with which the air weapon moves; the other, the fact that the fighting airplane is not stationary aloft but must return to the ground and to a safe landing area before fuel supply is exhausted. Therefore there is a vital time element in all aerial communications. The radio operator and technician aboard the airplane is a vital link in the air communications scheme. He must be capable of operating efficiently any of the two or three radio sets aboard the plane and, in addition, he must be skilled in the operation of direction finders, radio compass and other instruments.

The radio operator generally will be an enlisted man, a graduate of the Air Forces Technical Schools and, before assignment to long-range bombardment, a radio operator of considerable aerial experience. In peacetime our airplanes tour civil airways and the radio operator must be familiar with civil technique and Department of Commerce radio procedure. In wartime he must be familiar with the codes and must be skilled in coding and decoding all messages.

More than one plane of our military service, as well as of the airline companies, has been saved from disaster by the skill and experience of the radio technician aboard. His is a dual mission. He gives to the operating personnel on the ground the necessary data from the plane and he receives weather and other information for the plane crew.

THE MACHINE GUNNER

This is strictly a military specialty; there is no civil counterpart. It appeals to the old soldier type who likes a trigger in his hand and who likes to feel the power and effect of the whistle of the machine-gun bullet and the smooth operation of machine gun or cannon.

The machine gunner is a combat crew member on multi-seater fighters, observation and reconnaissance aircraft and is of a special importance on all types of bombardment. Some gunners will operate 30 or 50 caliber guns firing at a rate of 1,200 rounds per minute. Others will operate the slower firing, larger caliber, 20 mm. and 37 mm. guns with the bigger kick. Upon the shoulders of this air specialist rides the safety of the plane while in flight in areas infested by hostile pursuit. In combat the skill, coolness and courage of the aerial gunner spell the safety of the big bomber.

In our Army Air Forces aerial gunners are enlisted men especially selected and trained primarily in our technical and gunnery schools, with concluding courses involving much aerial practice in our tactical units.

OBSERVER AND AERIAL PHOTOGRAPHER

The observer and the aerial photographer are combat crew member specialists on observation and reconnaissance type aircraft. Cameras are now being added as standard equipment on bombing aircraft, which will require skilled operators as additional crew members aboard these types.

In the observation airplane the primary assignment and duty of the observer is to glean military information on the ground. In addition, he may observe artillery fire and execute infantry liaison missions which require him to observe troop movements, traffic on highways, location of battle lines and the checking and correction of maps. The observer also serves as machine gunner and covers and protects the rear hemisphere of his plane when attacked by hostile pursuit. Many an observation pilot who came out of the last war confirms our belief that good observers are born, not made. The normal period of training for an observer in our Army is at least one year. Since there is no civil counterpart to this air combat crew member, he will generally be a professional soldier who likes the air and is willing to train himself in the many and varied functions of the aerial observer and in the tactics of ground and sea units. Under expansion plans now in progress in the Army Air Forces, it is proposed to take a number of artillery and infantry officers and give them this special observation training.

While the aerial observer sometimes substitutes as aerial photographer on observation planes, generally in the reconnaisance and bombardment planes a photographic specialist, a separate combat crew member, especially trained in the operation of the expensive and intricate multi-lens cameras, will be aboard. With his nine-lens camera he will make photographic maps more than 200 miles in length and several miles in width in a single loading. The photographic specialist in our Army Air Forces is generally an enlisted man or noncommissioned officer, a graduate of the photographic branch of our Air Forces Technical Schools.

With the success of experimentation in night photography, photographing through overcast and with colored photography now almost through the experimental stage and a practical

actuality, the duties and responsibilities of the aerial photographer will greatly expand.

No phase of military work has made greater progress in recent years than aerial photography. With the discovery that photography can defeat camouflage and that it is not barred by clouds or darkness, new fields are opened in the realm of military science for the aerial cameraman and his new and powerful machines.

THE MAINTENANCE CREW

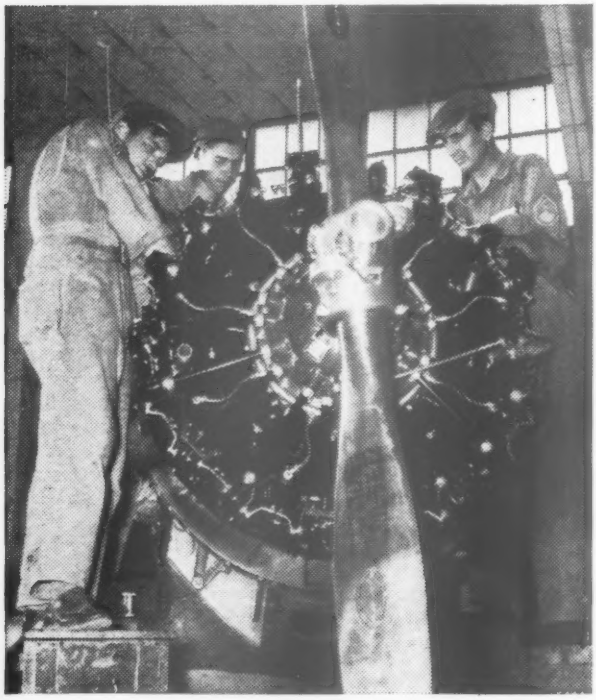
It has been said that in the air force it takes 10 men on the ground to keep one man in the air. In our projected Air Forces of 160,000 men, less than 12,000 of them will be pilots; this illustrates the soundness of the 10 to one ratio. Actually, however, with the increasing larger proportions of bombardment aircraft, with multiple combat crews, the ratio of the ground man to the airman is about five to one.

An old airman in extolling the virtues of the maintenance mechanic once said proudly, "These mechanics literally hold the planes aloft with their hands."

The success of an air force will depend in great measure on the skill, training and loyalty of its ground maintenance crews. There are a large number of ground aviation specialties, the principal of which are the airplane mechanic, engine mechanic, aircraft metal worker, aircraft parachute repair man, photographic technician, electrician, radio technician, armament expert and weather specialist.

The best quick insight to the operation of ground crews can be given by examining the process and procedure from the time an airplane lands until it is inspected and pronounced ready for the take-off on the next mission. As it taxies to its flying line and when its great motors are stopped, it is taken over by a ground crew of four to 12 men, depending upon the size of the plane. One of these men with a requisite number of helpers will check the airplane structure, its movable control connections and surfaces, its wings and fuselage, and its many constituent parts and see that they are oiled, safetied and made airworthy. Other members of the crew, the engine mechanics, will devote themselves exclusively to the power plants and their many accessories, their miles of electrical wiring, hundreds of feet of plumbing tubing and several hundred instruments. These men will work diligently six to 10 hours per day on their airplane, recording on visual charts each complete operation and inspection made and testify, by the certificate of their initials, that every mechanical part is in order. The radio specialist in the combat crew will check all radio equipment and try it out by calls to the airdrome station.

U. S. Army Air Forces pilots will rely on many thousands of skilled aero engine mechanics to keep their planes flying.



The crew chief, the boss of this skilled labor gang, watches and supervises over the whole operation and gives such advice as his long years of experience and knowledge of the plane deems necessary.

The Army Air Forces today has 5,000 to 7,000 of these trained airplane and engine mechanics and the Air Forces of the spring of 1942 will have five times that number. They range in grade from apprentices, who are privates and privates first class and air mechanics second class, to men of 10 to 15 years' service who are corporals, sergeants, master sergeants and air mechanics first class.

The crew chiefs generally are men of long service who hold the rank of master or technical sergeant. Over all these combat crews, each for its individual airplane, supervises a hangar chief and a line chief per squadron. These will generally be two master sergeants, men of 20 years or more of service and of long experience in the supervision of shops, overhaul, maintenance and repair crews; men who, in addition to their technical skill, possess considerable executive ability. The primary consideration for the maintenance man is dependability and trustworthiness, plus the application of a reasonable mechanical skill.

The Army trains its own mechanics in its own technical schools or in civil schools especially selected for certain courses. The great majority of Army maintenance specialties have civil counterparts and our Air Forces trained men are eagerly sought by airline operators and by aircraft manufacturing establishments. Not every man in the Air Forces is a trained specialist, but it is undoubtedly true that no other military organization has a higher percentage of trained specialists in its ranks. Under the Air Forces system every soldier is permitted to apply for any course of training; all he must do is demonstrate his ability satisfactorily to complete the course he desires. This is determined by a simple test, devised to insure that the man who can pass it possesses the ability and aptitude for the specialty he would follow.

The Army Air Forces, aside from its purely military function of providing air defense, is a ground training school, the largest aviation mechanics' training school in the country. It now has more than 70,000 men and two years hence expects to have 160,000 men in the prime of life to shelter, equip, feed, train and organize into a capable mechanical, technical and fighting force to man our air frontiers.

The aviation industry is new—just one generation old, yet now nearly 150,000 men are employed in its factories, with 250,000 as the figure to be reached a year hence. A considerable proportion of them received their initial training in the Army Air Forces. Our military organization, therefore, plays an important role in supplying skilled labor to industry. During the next decade literally millions of men must receive this training if our industry is to reach the stature to supply the air force we will need. So, the Air Forces is not disappointed when several thousands of its men leave annually with Army training in Air Forces schools and squadrons and go to the civil industry.

PARACHUTE TROOPS AND AIR INFANTRY

No consideration of winged warriors would be complete, in the light of recent air experiences abroad, without a consideration of parachute troops and air infantry. There is a reasonable distinction between them. Parachute troops are placed "in the right place at the right time" by being delivered from airplanes by parachute. Air infantry is so-called merely because infantry soldiers use the air vessel as a means of transport from the camp and bivouac to the battlefield.

The tempo of battle, as many have observed recently, has

These young men are part of the Army's paratroops in training with the 501st Parachute Battalion at Ft. Benning, Ga. New type 'chutes, clothing, guns have been designed by engineers at Wright Field.

speeded up tremendously, but the ultimate in our time will be reached not by the Panzer Divisions, not by the motorized, mechanized brigades, but by parachute troops and air infantry.

Gen. William Mitchell returned from the first World War with this conception of parachute troops. At his direction it was demonstrated at Kelly Field, before the procedure became commonplace in Russia and Germany, that troops with machine guns could be and were landed by parachute with their automatic weapons, and could have them set up and in operation in a brief span of time—less than three minutes by actual test. After these early experiments, the use of parachute troops languished in this country. Such was not the case abroad, however. It was well known to our military observers that there was tremendous emphasis placed upon this new form of troop movement, particularly in the Russian army. In one operation more than 1,000 men were dropped in a large-scale maneuver on the Russian steppes.

It remained, however, for the Germans to demonstrate in warfare the great power of this new weapon by their operations in Czechoslovakia, Norway, and later and more extensively in Holland [Not to mention Crete.—Ed.]

On the morning of May 10, 1940, the startled Holland burghers, as the mists cleared from their meadows, found German parachute troops widely scattered over their countryside, quickly moving to strategic points. They found their airdromes occupied by air infantry and held against their own troops, protecting safe landing areas for hostile aircraft.

Here in Holland was the ideal opportunity for this weapon, parachute troops and air infantry. By the nature of the terrain, long bridges and causeways cross streams and estuaries, without control of which an advancing army could be long delayed. It was necessary that the defenders of Holland be not permitted to destroy these bridges. German parachute troops were dropped from the air with their weapons, equipment and ammunition, in sufficient quantity to protect these bridge heads and hold these indispensable channels of communication for the use of incoming Panzer Divisions and the German mechanized hordes. Through the complete and thorough employment of these air troops, a conquest of Holland was made possible in a few weeks, a conquest which the boldest military tacticians would not have predicted as possible in less than months.

In our Army this striking example has not gone unnoted. In the summer of 1940 at Ft. Benning, Ga., there was begun the training of a parachute platoon. The Air Corps Matériel Division, Wright Field, Dayton, O., developed special parachutes for jumpers and their heavy equipment. Many practice jumps have been made and that nucleus, the especially selected and highly trained platoon, has now been expanded to a battalion. Enlistment in the parachute battalion has been on a voluntary basis and there has been no dearth of volunteers. The American soldier is especially well suited to this precarious duty, since he possesses the courage, the aptitude and the technical background to develop it to ultimate efficiency.

THE SERVICES

The Army Engineers, the Chemical Warfare Service, the Ordnance Department, the Signal Corps, the Medical Corps and the Quartermaster Corps perform vital services for the Army Air Forces. Under the new program more than 40,000 of these men will be detailed to our Air Forces of 160,000 men. The Engineers build the airdromes and technical buildings in wartime. They are charged with the camouflage of airdromes and military installations to reduce their visibility and the likelihood of attack from the air. Air Engineering regiments have recently been organized to be trained in the new problems of airport construction and development, particularly in the building of wartime auxiliary airdromes, which will permit

an air force to disperse and thus render it a less inviting target for air attack.

The Chemical Warfare Service has long been closely affiliated with the Army Air Forces in the development of chemical equipment to be carried on aircraft. Thus far in the second World War chemicals, except for smoke, have been little used. In the first World War, toxic chemicals were extensively used and it is unwise and unsafe to assume, because they have not been used thus far, that they will not be used again. The chemical soldiers on duty with the Air Corps are trained in decontamination of airdromes, airplanes and technical buildings and in the providing of forced air circulation in underground shelters.

There is of necessity a large and important Ordnance Department at each air base and a smaller detachment with each fighting squadron. These are the men who supervise the loading of bombs, the maintenance of machine guns and cannon. In short, they are the caretakers and technicians for the weapons the fighting plane carries. The Ordnance Department is responsible for the development of new types of bombs and new types of guns. They supply also flares and other illuminating equipment which make night operations effective.

A considerable detachment of the Signal Corps has been present with the Air Forces since it began. As a matter of fact, originally, the first Army Air Service was a section of the Signal Corps. The Signal Corps, as the name implies, supplies the radio equipment and other signaling devices which permit plane to plane and plane to ground and other communication. The Signal Corps, in conjunction with the Air Corps, maintains an experimental laboratory as a part of the Matériel Division, Wright Field, where the radio signaling devices are tested and applied to aircraft. The Signal Corps is charged with the procurement and supply of all signal equipment and devices.

The Quartermaster Corps will provide more than 30,000 men as a great army of housekeepers to supervise the messing, the sheltering and the clothing of the Army's air component.

The Medical Corps provides the trained doctors, nurses and specialists to care for the sick and wounded. They operate hospitals, ambulance service, and provide the physical examinations which insure the continued fitness of the flyer.

All of these services, representative of the older branches of the military service, have demonstrated one remarkable thing in common. They have applauded the strides and the advances of the air branch of the military service and have co-operated enthusiastically and efficiently toward the building of a proper air defensive establishment. To them must go in no small measure the just praise for the eventual accomplishment of an adequate air defense.

Chapter Three

AIR BASES—THE EAGLE'S NEST

". . . this Government has acquired the right to lease Naval and air bases in Newfoundland, and in the islands of Bermuda, the Bahamas, Jamaica, St. Lucia, Trinidad and Antigua, and in British Guiana. . . . It is an epochal and far reaching act of preparation for continental defense in the face of grave danger. . . . This is the most important action in the reinforcement of our national defense that has been taken since the Louisiana Purchase."

—The President, in a message to Congress, Sept. 3, 1940

AIR bases as early as the Spanish Civil War three years ago were quite aptly termed the eagle's nest. In its broadest application and as the term is applied in our own Combat Command, an air base is an area and not a locality. It comprises a central airdrome with many outlying or dispersion airdromes, so that airplanes can be scattered when air attack is imminent. The soundness of such dispersion is being demonstrated daily in England, where airdromes are attacked with bombs of assorted sizes and yet comparatively few planes are destroyed.

In its strictest application and most limited sense, it is merely a landing and take-off area for aircraft. By the light of this definition, aircraft carriers have sometimes been termed floating air bases. Of late with the development of powerful, fast landing, little planes and of heavy giant bombers, this landing area takes on added significance.

During the last war, when the average airplane weighed but little more than a ton and landed at a speed of 50 to 60 m.p.h., many of the bases in France could be and were merely improved farm or pasture land. Runways and landing strips were unheard of.

Dotted all over the United States at the regular Army stations and near the great centers of population are establishments which are readily picked up and identified from the air as airdromes, because of the giant white concrete runway crosses splashed across their surfaces. Our military leaders have worried considerably that these airdromes are advertising their existence to all and sundry from far and near, merely inviting air attack.

Abroad, particularly in Germany, the airport builders have been more realistic, being closer to the struggle. They could smell the battlefires, consequently were farsighted enough to refrain from building concrete runways and landing surfaces difficult to camouflage or hide. The character of the soil and drainage permitted cultivation of a heavy turf surface. They even went further in their efforts to disguise their airports and built roads, walks and hedges, all camouflage, which broke their regular lines and made them almost impossible to pick up from the air. By the light of recent conflicts the wisdom of these precautions have become all too apparent, not only in Germany but in Great Britain as well.

PERMANENT AIR BASES

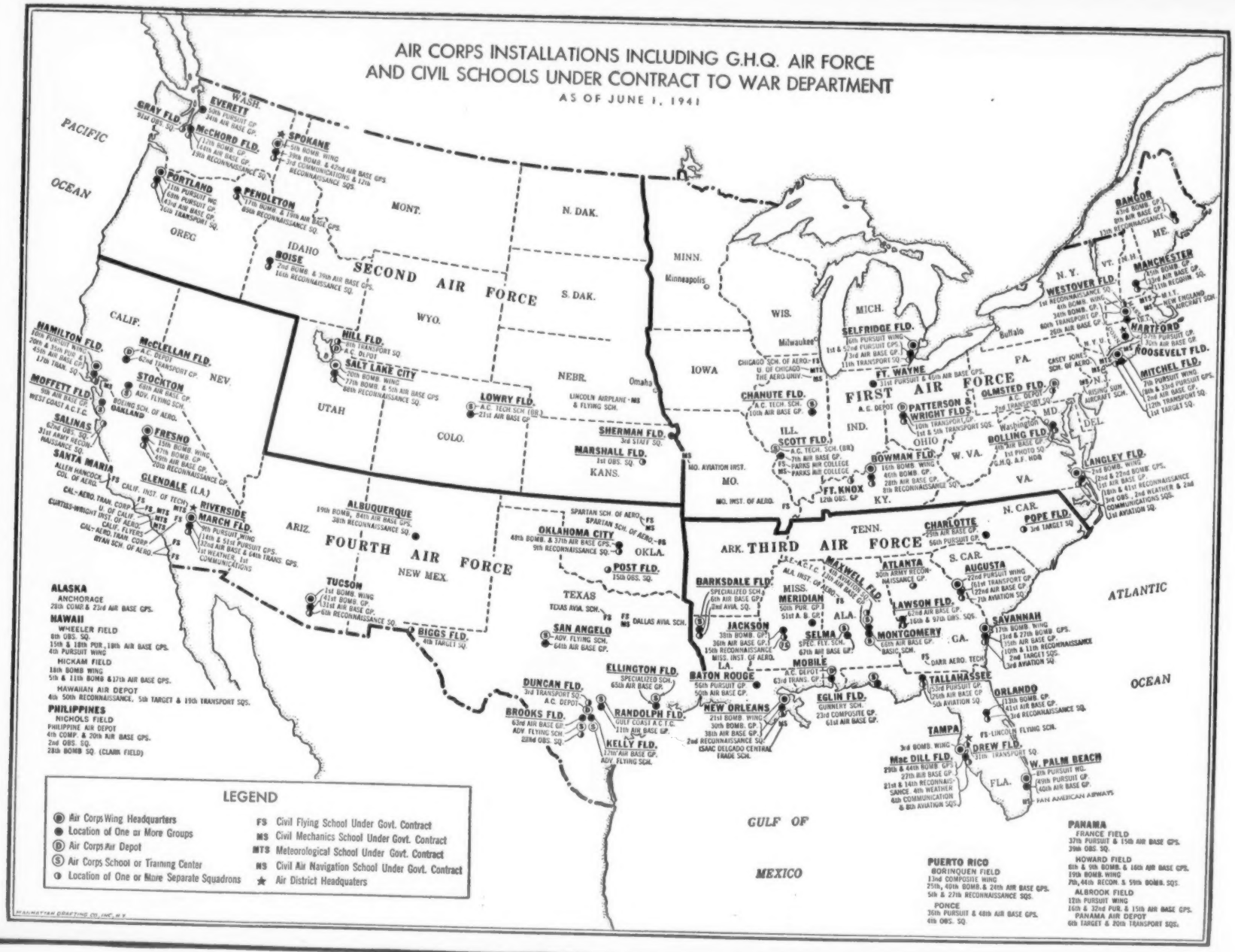
In our country established military flying fields serve as the nucleus for our air bases. Here is developed the home airdrome, the center of the great wheel-like area which is the true air base, with the home flying field as the hub.

In addition to the landing area which is but a minor, although nonetheless important feature of the air base, here are located the hangars, the shops, the warehouses, the gasoline storage facilities, the bomb and ammunition depots, the permanent quarters for combat and maintenance crews, the messing and recreation facilities and the maintenance and repair facilities. These vast installations cost from $7,000,000 to $14,000,000 each and in peacetime serve as the home of one or two groups. Generally, our Air Forces prefers one-group air bases, following the principle of not having too many eggs in one basket.

Extending outward from this home airdrome on 50- to 60-mile radii of a circle are the other components of the true air base, the outlying or dispersion flying fields, the bombing and gunnery ranges, the night flying practice areas, the radio stations, the homing devices, the blind-landing systems, the underground gasoline and bomb storage and all the other tactical necessities and technical mechanisms necessary to military air operations.

Where the terrain affords an abundance of suitable flying fields, the air base generally will have outlying or dispersion fields for each squadron. Sometimes these will be broken down into fields for each flight. Every effort will be made to construct fields which will not require hard surfacing of the runways. Where that is impossible, the tendency now is to use metal strips or wire mesh. Grass grows up through the interstices, helps in camouflaging the field and shields from view the metal which provides an all-weather landing field for all types of planes.

Back now to a thorough inspection of the air base proper, or the nucleus airdrome, we find located generally along the parking mat, known in aviation parlance as the *line*, a series of great hangars, generally at least 125 feet in width and 250 to 300 feet in length. An endeavor is made to supply at least one hangar for each operating squadron, so that there will be


AIR CORPS INSTALLATIONS INCLUDING G.H.Q. AIR FORCE
AND CIVIL SCHOOLS UNDER CONTRACT TO WAR DEPARTMENT
AS OF JUNE 1, 1941
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
SECOND AIR FORCE
THIRD AIR FORCE
FOURTH AIR FORCE
FIRST AIR FORCE
WASH.
OREG.
CALIF.
IDAHO
NEV.
MONT.
WYO.
UTAH
ARIZ.
NEW MEX.
COLO.
N. DAK.
S. DAK.
NEBR.
KANS.
OKLA.
TEXAS
MINN.
IOWA
MO.
ARK.
LA.
WIS.
ILL.
MICH.
IND.
OHIO
KY.
TENN.
MISS.
ALA.
GA.
FLA.
S. CAR.
N. CAR.
VA.
W. VA.
PA.
N. Y.
MD.
DEL.
N. J.
VT.
N. H.
ME.
EVERETT
GRAY FLD.
McCHORD FLD.
SPOKANE
PORTLAND
PENDLETON
BOISE
HAMILTON FLD.
McCLELLAN FLD.
STOCKTON
MOFFETT FLD.
OAKLAND
SALINAS
FRESNO
SANTA MARIA
GLENDALE (LA.)
RIVERSIDE
MARCH FLD.
HILL FLD.
SALT LAKE CITY
LOWRY FLD.
SHERMAN FLD.
MARSHALL FLD.
ALBUQUERQUE
TUCSON
BIGGS FLD.
OKLAHOMA CITY
POST FLD.
SAN ANGELO
DUNCAN FLD.
BROOKS FLD.
KELLY FLD.
RANDOLPH FLD.
ELLINGTON FLD.
BARKSDALE FLD.
JACKSON
BATON ROUGE
NEW ORLEANS
MERIDIAN
SELMA
MOBILE
EGLIN FLD.
MAXWELL FLD.
CHANUTE FLD.
SCOTT FLD.
FT. KNOX
BOWMAN FLD.
PATTERSON & WRIGHT FLDS.
FT. WAYNE
SELFRIDGE FLD.
OLMSTED FLD.
BOLLING FLD.
ATLANTA
AUGUSTA
CHARLOTTE
POPE FLD.
LAWSON FLD.
MONTGOMERY
TALLAHASSEE
SAVANNAH
ORLANDO
TAMPA
DREW FLD.
Mac DILL FLD.
W. PALM BEACH
LANGLEY FLD.
WESTOVER FLD.
MITCHEL FLD.
HARTFORD
MANCHESTER
BANGOR
ALASKA
ANCHORAGE
HAWAII
WHEELER FIELD
HICKAM FIELD
HAWAIIAN AIR DEPOT
PHILIPPINES
NICHOLS FIELD
PHILIPPINE AIR DEPOT
PUERTO RICO
BORINQUEN FIELD
PONCE
PANAMA
FRANCE FIELD
HOWARD FIELD
ALBROOK FIELD
PANAMA AIR DEPOT
LEGEND
Air Corps Wing Headquarters
Location of One or More Groups
Air Corps Air Depot
Air Corps School or Training Center
Location of One or More Separate Squadrons
FS Civil Flying School Under Govt. Contract
MS Civil Mechanics School Under Govt. Contract
MTS Meteorological School Under Govt. Contract
NS Civil Air Navigation School Under Govt. Contract
Air District Headquaters

housing for maintenance and storage of tools and airdrome equipment. In the middle twenties, in building Army flying fields, an effort was made to house all aircraft. Military airplanes are constructed almost entirely of metal now and they have reached a size which makes housing problems more difficult. They will be stored generally in the open at all of our military airdromes.

In front of the hangar line are parking areas for this open-air storage of aircraft, for their warm-up before take-off and for servicing and minor repair. Searchlights keep this parking area flooded at night to facilitate guard, fire protection and eliminate possibilities of theft and sabotage.

Lean-tos to the squadron hangars will contain operations offices, schoolrooms and mechanics' supply rooms. There also will be supply and tool rooms. Another essential and separate room will be devoted to the storage of machine guns and other detachable military equipment. The squadron hangar thus becomes the workshop for 150 mechanics and technicians and 30 to 40 pilots.

In the center of this hangar and flying line will be an especially constructed administration building, the seat of air base government and administration. Here are the offices of the commanding officer and adjutant, operations officer, quartermaster, flight surgeon and clerical and administrative personnel. Here, also, is located the central weather station, now an absolutely essential activity in each air base. Another indispensable unit in this central administration building, generally atop the structure, is the field control tower. Here trained observers note the air space in the airdrome area and traffic on the airdrome and, by visual signal or rado, contact all incoming flyers, greeting them with landing directions.

Back of the flying line are the shops and the supply warehouses. The shops will be equipped to make engine changes, to repair or change instruments and to do all second-line maintenance. First-line maintenance, minor repair, usually that which can be completed in a 48-hour period, is performed on the flying line by the squadron mechanics. Second-line maintenance, work of a more complicated nature, is done by the engineering establishments of the air base. Third-line maintenance, generally that requiring major repair work or replacements, is performed in the military depots, one of which is located centrally in each air district.

Generally, two great depot buildings serve as supply warehouses, one for Air Forces items of equipment, the other for Quartermaster or housekeeping supplies.

Other technical buildings in this second, or maintenance line, will house Signal, Ordnance, Engineering and Chemical supplies.

In this second-maintenance line, generally on a corner of the field somewhat separated from other structures, where its tall towers will not interfere with flying, is the post radio station.

Another important item on the maintenance line are the garages, both for Air Corps technical vehicles and staff and reconnaissance cars. The average group will have 50 to 60 technical vehicles to facilitate the rapid movement of its ground echelon. Quartermaster vehicles in almost equal number provide the necessary transportation for all housekeeping functions.

The technical structures on the maintenance line merit special consideration. The first is the parachute loft. On a group air base the parachute hut will maintain about 300 parachutes, requiring the employment of 20 to 30 specially trained parachute technicians.

The photographic building contains dark rooms, drying rooms, enlarging rooms, map-making and mosaic rooms and locked and specially ventilated storage houses for valuable cameras. On the average base group about 30 photographic specialists will be engaged. Formerly only observation or reconnaissance groups had photographic sections. Cameras now are standard equipment on all aircraft except fighters.

The morale of personnel, flying and mechanical, generally will be no better than the accommodations for food, shelter and recreation. Since the average group air base houses about 1,500 people in its third-line or housekeeping area, there is every provision usually found in the small American village.

Generally considerably removed from the flying and maintenance line and the quarters area is provision for underground gasoline, bomb and ammunition storage. The Air Forces have storage dumps located at strategic points in all operating areas.

Also generally removed as far as possible from high explosives' storage and flying-line activity, but reasonably accessible to the quarters area, is the air base hospital.

TEMPORARY AIR BASES

Ordinarily the subject of temporary air bases would concern a maneuver area or a battle area only. Early in 1940, however, temporary air bases became a vital concern to our expanding Army Air Forces. The 1940 Air Forces of 60 squadrons required but 17 permanent bases to house it. With the increased authorization by the 76th Congress, providing for Air Forces of 60 groups or 288 squadrons, additional bases were at once necessary. There was not time to build permanent air bases. The decision was made to select more than 30 temporary air bases, locating them on civil airdromes which had landing areas sufficient in extent and which were situated reasonably close to towns of sufficient size to afford quarters for married officers and noncommissioned officers. These temporary air bases, as are the permanent ones, generally are of a size to house a group, four squadrons, with the attendant necessary service personnel.

Temporary air bases have one advantage. They more closely resemble the advance or maneuver airdrome and give the flying personnel the advantage of semi-field experience. They have another advantage which eventually may become all too apparent. In time, when the war clouds pass and emergencies seem less imminent, these can be abandoned without great economic loss and the reduced flying establishment can be drawn back into its permanent bases.

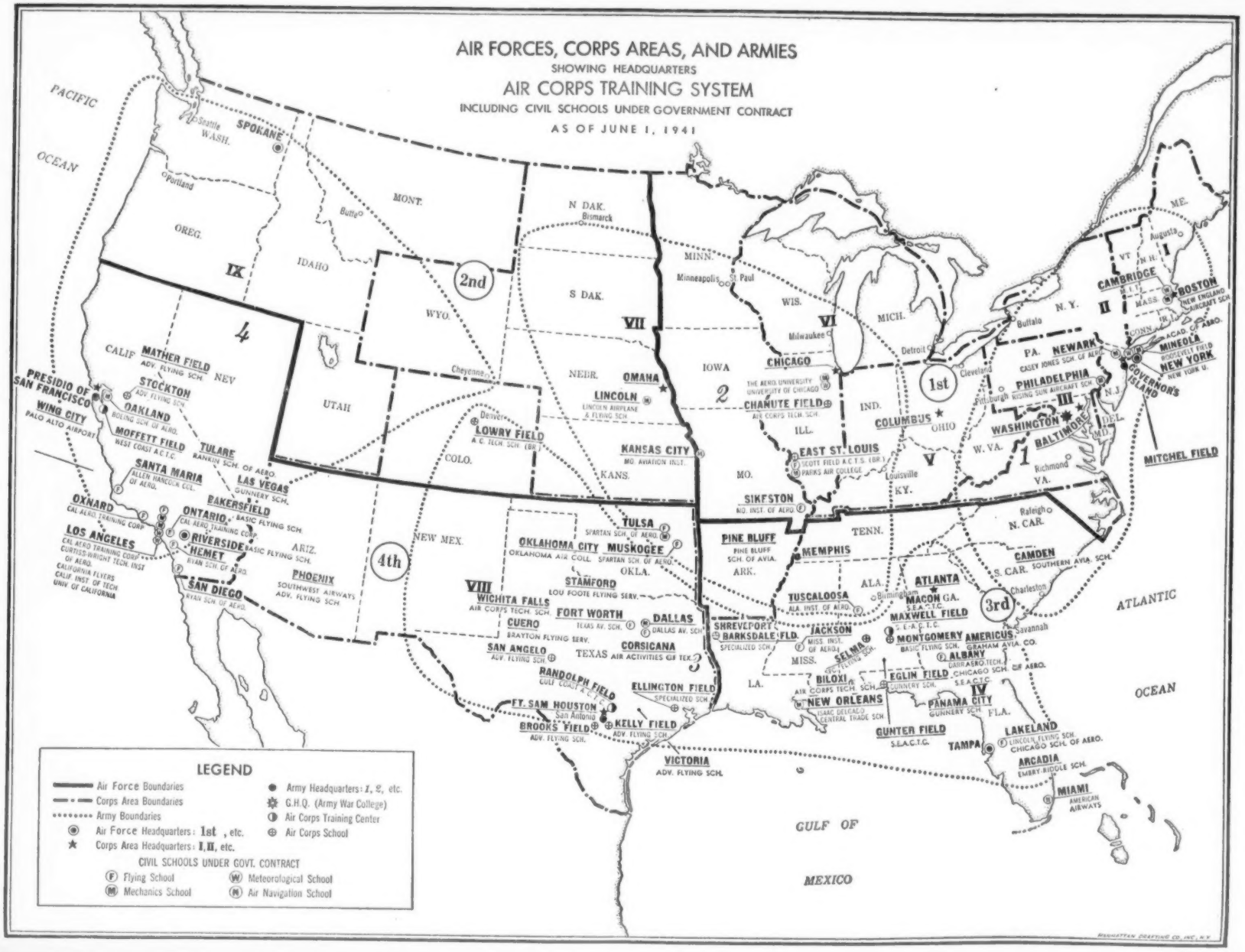
The disadvantages lie in the fact that, having induced the temporary boom in the communities near which they were located, there is a consequent deflation upon their abandonment, with attendant pressure to maintain them on an operating status regardless of priority from national defense requirements. Also there are some additional hardships on military personnel housed in temporary bases, which make it a serious problem to maintain morale at the requisite high level. Training is never as satisfactory under field or temporary air base conditions as when units are housed in permanent bases.

LOCATION OF AIR BASES

Theoretically the air base should be located to serve the interests of tactics and strategy, particularly the latter. Undoubtedly political and other considerations have sometimes been allowed to color decisions as to the location of permanent air bases. Geographically air bases should be located well forward in the area to be defended, but not closer than 50 miles to the coast lines and territorial boundaries. This latter consideration is not always possible, but it greatly facilitates air base defense.

A consideration not so important in the past, but which will be paramount in the future, concerns the terrain. The ideal area for an air base would be a level plain, adjacent to a wooded area and hills, bluffs, or other elevations. The latter will allow for the dispersion of aircraft and their natural camouflage in lanes of trees to minimize damages and losses from bomb attack and will also afford a possibility for underground storage if necessary and if economic conditions permit.

Under the national military policy, which is defensive, it behooves the Government carefully to study diplomatic negotiations and international relations—in short, to determine the direction from which the air threat will come. At least one major base and a large number of sub-bases should be located well forward in that direction. The defending air force must


AIR FORCES, CORPS AREAS, AND ARMIES
SHOWING HEADQUARTERS
AIR CORPS TRAINING SYSTEM
INCLUDING CIVIL SCHOOLS UNDER GOVERNMENT CONTRACT
AS OF JUNE 1, 1941
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
IX
4
2nd
VII
VI
1st
2
IV
V
3rd
1
4th
VIII
III
II
I
SPOKANE
Seattle
WASH.
Portland
OREG.
Butte
MONT.
IDAHO
N. DAK.
Bismarck
MINN.
Minneapolis
St. Paul
S. DAK.
WYO.
Cheyenne
NEBR.
OMAHA
LINCOLN
LINCOLN AIRPLANE & FLYING SCH.
IOWA
WIS.
Milwaukee
CHICAGO
THE AERO. UNIVERSITY UNIVERSITY OF CHICAGO
CHANUTE FIELD
AIR CORPS TECH. SCH.
MICH.
Detroit
Buffalo
N. Y.
Cleveland
PA.
NEWARK
CASEY JONES SCH. OF AERO.
PHILADELPHIA
Pittsburgh RISING SUN AIRCRAFT SCH.
N. J.
WASHINGTON
BALTIMORE
DEL.
MD.
W. VA.
Richmond
VA.
Louisville
KY.
OHIO
COLUMBUS
IND.
ILL.
EAST ST. LOUIS
SCOTT FIELD A.C.T.S. (BR.)
PARKS AIR COLLEGE
SIKESTON
NO. INST. OF AERO.
MO.
KANS.
COLO.
Denver
LOWRY FIELD
A.C. TECH. SCH. (BR.)
KANSAS CITY
MO. AVIATION INST.
UTAH
NEW MEX.
ARIZ.
TENN.
Raleigh
N. CAR.
S. CAR.
Charleston
Savannah
ALA.
Birmingham
ARK.
OKLA.
TEXAS
LA.
MISS.
FLA.
Tampa
ME.
Augusta
VT.
N. H.
MASS.
CONN.
CAMBRIDGE
M.I.T.
BOSTON
NEW ENGLAND AIRCRAFT SCH.
ACAD. OF AERO.
MINEOLA
WINSLEY FIELD
NEW YORK
NEW YORK U.
GOVERNOR'S ISLAND
MITCHEL FIELD
CALIF.
MATHER FIELD
ADV. FLYING SCH.
NEV
PRESIDIO OF SAN FRANCISCO
STOCKTON
ADV. FLYING SCH.
OAKLAND
BOLLING SCH. OF AERO.
WING CITY
PALO ALTO AIRPORT
MOFFETT FIELD
WEST COAST A.C.T.C.
TULARE
RANKIN SCH. OF AERO.
SANTA MARIA
ALLEN HANCOCK COL. OF AERO.
LAS VEGAS
GUNNERY SCH.
BAKERSFIELD
BASIC FLYING SCH.
OXNARD
CAL AERO. TRAINING CORP.
ONTARIO
CAL AERO. TRAINING CORP.
RIVERSIDE
BASIC FLYING SCH.
HEMET
RYAN SCH. OF AERO.
LOS ANGELES
CAL AERO. TRAINING CORP.
CURTISS-WRIGHT TECH. INST.
OF AERO.
CALIFORNIA FLYERS
CALIF. INST. OF TECH.
UNIV. OF CALIFORNIA
SAN DIEGO
RYAN SCH. OF AERO.
PHOENIX
SOUTHWEST AIRWAYS
ADV. FLYING SCH.
TULSA
SPARTAN SCH. OF AERO.
OKLAHOMA CITY
OKLAHOMA AIR COLL.
MUSKOGEE
SPARTAN SCH. OF AERO.
STAMFORD
LOU FOOTE FLYING SERV.
WICHITA FALLS
AIR CORPS TECH. SCH.
FORT WORTH
TEXAS AV. SCH.
DALLAS
DALLAS AV. SCH.
CUERO
BRAYTON FLYING SERV.
CORSICANA
TEXAS AIR ACTIVITIES CO.
SAN ANGELO
ADV. FLYING SCH.
RANDOLPH FIELD
GULF COAST A.C.T.C.
ELLINGTON FIELD
SPECIALIZED SCH.
FT. SAM HOUSTON
San Antonio
BROOKS FIELD
ADV. FLYING SCH.
KELLY FIELD
ADV. FLYING SCH.
VICTORIA
ADV. FLYING SCH.
PINE BLUFF
PINE BLUFF SCH. OF AVIA.
MEMPHIS
SHREVEPORT
BARKSDALE FLD.
SPECIALIZED SCH.
JACKSON
MISS. INST. OF AERO.
SELMA
ADV. FLYING SCH.
TUSCALOOSA
ALA. INST. OF AERO.
ATLANTA
MACON GA.
S.E.A.C.T.C.
MAXWELL FIELD
S.E.A.C.T.C.
MONTGOMERY
BASIC FLYING SCH.
AMERICUS
GRAHAM AVIA. CO.
ALBANY
GRAHAM AERO. TECH.
CHICAGO SCH. OF AERO.
EGLIN FIELD
GUNNERY SCH.
S.E.A.C.T.C.
BILOXI
AIR CORPS TECH. SCH.
NEW ORLEANS
ISAAC DELGADO CENTRAL TRADE SCH.
PANAMA CITY
GUNNERY SCH.
GUNTER FIELD
S.E.A.C.T.C.
LAKELAND
LINCOLN FLYING SCH.
CHICAGO SCH. OF AERO.
ARCADIA
EMBRY-RIDDLE SCH.
MIAMI
AMERICAN AIRWAYS
CAMDEN
S. CAR. SOUTHERN AVIA. SCH.
LEGEND
Air Force Boundaries
Corps Area Boundaries
Army Boundaries
Air Force Headquarters: 1st, etc.
Corps Area Headquarters: I, II, etc.
Army Headquarters: 1, 2, etc.
G.H.Q. (Army War College)
Air Corps Training Center
Air Corps School
CIVIL SCHOOLS UNDER GOVT. CONTRACT
(F) Flying School
(M) Mechanics School
(W) Meteorological School
(N) Air Navigation School
MANHATTAN DRAFTING CO., INC., N.Y.

be between the marauding air enemy and the vital targets which are to be defended.

In the United States, if our military leaders believe that an air threat will come from across the Atlantic, they will probably make two determinations as to the route of advance that will be followed. The line of hostile air approach may be through Newfoundland and the North Atlantic, headed toward our critical industrial area. This consideration undoubtedly motivated the location of the new Northeast Air Base near Springfield, Mass.

However, the air attack may come from across the Atlantic by way of the Caribbean theater in the South Atlantic. A major air base and subsidiary dispersion airdromes, then, should be located in the southeast section of the United States. Such considerations undoubtedly influenced the location of the Southeast Air Base at Tampa, Fla.

In opposing a threat from the North Pacific area by way of the Aleutian Islands and Alaska, air bases are indicated for the northwestern part of the state of Washington. Our Government is now completing a major air base at Tacoma, Wash., which fulfills this requirement.

An attack by air from floating bases in either ocean should be met by aircraft dispatched from the closest point on the Atlantic and Pacific. To comply with this requirement we have air bases located at Langley Field, Va., and near San Francisco and at March Field, Riverside, Cal.

Behind these forward major bases from which our tactical units, our bombers and fighter groups, will operate, are established a second line of tactical bases farther removed from imminent attack. In rear of this second line of tactical bases come the supply bases or depots and the training bases or flying schools.

Not all of our major bases are located at the most important points, measured by tactical and strategic standards with due regard to geographic locations from which possible threats may come. One reason for this is that several were located long before air power took its place in the present trinity of warfare. During the last war many ground flying schools were erected near centers of population. The Army bought these sites, erected base installations and, at the close of the war, when the training establishments were disbanded, these naturally were occupied by tactical units. With the peacetime, piecemeal appropriations, these wartime flying, training fields gradually were expanded into permanent, major air bases. That accounts for the location of such bases as Langley Field, Va., and Mitchel Field, N. Y., within range of naval gunfire if a hostile fleet were able to reach our shores.

While a coastal or border location for air bases is not the ideal, it is essential that the air base be located well forward in order to conserve fuel and extend the range of aircraft. It is necessary for the bomber and the reconnaissance plane to get as far out to sea as possible, in order to attack the enemy before he can dispatch his aircraft against our vital objectives. Where permanent air bases are established too far inland from coast line or boundary, forward or advanced airdromes will be necessary. Planes will be dispatched from permanent bases, alight on these temporary forward airdromes for refueling and for taking on bombs and, after returning from long-range or reconnaissance missions again will land on these advanced airdromes for refueling prior to return to permanent bases.

The establishment of air bases in the United States must consider one other important factor and that is the great industrial area which must be defended. A line drawn from Detroit to St. Louis and thence eastward to Baltimore will outline the western and southern limit for the great majority of the manufacturing establishments whose continual operation is vital to preparations for war and to the continuing supply of armies and air forces. Our air bases must be located so that they will lie, where possible, between this vital area and the line of flight approach of the invading enemy bomber.

Two new and important geographical areas recently have come into our national defensive picture for air base construction. The first of these, Alaska, lies along the natural air route from the old world to the new. A belated recognition of the importance of Alaska in our air defensive scheme has caused us to build one major air base at Anchorage, Alas., and a very important cold-weather experimental station at Fairbanks. No more important step has been taken in air base construction in our time.

The other theater of recent concern lies in the Caribbean. A chain of islands, the Lesser Antilles, comprising the Windward and Leeward groups, Haiti, Puerto Rico and the Virgin Islands, extends from Trinidad near the northeast coast of South America in a perfect arc to Cuba and Florida. Leading airmen have contended for years that the establishment of air bases properly dispersed in this island chain was a necessity for adequate air defense for our eastern seaboard.

Lately permission has been obtained for the leasing of land and the construction of air bases at Trinidad, Santa Lucia, Antigua, Jamaica and Bermuda. Hand in hand with these new bases two other important forward airdrome sites have been acquired, the one in British Guiana on the northeast coast of South America and the other in Newfoundland. The provision of these advance air bases will do more for the security of this country against any air threat coming out of the Atlantic or from Europe and Africa and in providing protection for the Panama Canal than any other phase of national defensive planning.

These, combined with our new base in Puerto Rico, will give our bombing groups complete command of the western half of the Atlantic and will build a giant fence to guard the airways extending from the northern coast of South America for 4,000 miles to the frozen coast of Labrador.

UNDERGROUND AIR BASES

Rumors coming out of foreign lands have pointed consistently for a number of years to increased emphasis on underground air bases. No military secret has been so carefully guarded by foreign nations as the extent to which they have gone to underground bases and as to the type of construction and structures placed in these establishments.

Here in the United States we have not yet gone that far. The principal reason for our failure thus far to put air bases underground can probably be laid to two principal conditions: first, the fact that air attack is not immediately imminent; second, the great cost of such installations. An air base which costs from $7,000,000 to $14,000,000, if duplicated underground, would cost at least six times that figure. Our military leaders have believed thus far that such costs are prohibitive and that the danger is not sufficiently pressing to make this expenditure necessary. This matter of placing air bases underground is probably one which will not be squarely faced in this country until hostile bombs have begun to inflict serious damage and then, as some of the combatants abroad have found to their chagrin and dismay, it will be too late.

England has found that by dispersing the planes singly—with earth embankments forming individual protective areas—the necessity for underground hangars for operating airplanes is eliminated.

AIR BASES FOR HEMISPHERE DEFENSE

Since our national policy is to include hemisphere defense, a new air base problem is at once thrust forward. If our Air Forces is ever to operate successfully outside the United States, it can do so only if adequate provision has been made for air bases.

Perhaps the number one air base problem, now that the acquisition of the Caribbean bases is an actuality, concerns negotiation with the other nations of the Western Hemisphere for the mutual erection of adequate air base establishments. Location of these bases is easily determinable by applying tactical and strategic yardsticks.

THE PROTECTION OF AIR BASES

The number one problem after the construction of an air base lies in its defense. Bases built on the surface of the

ground which lie in the path of invading aircraft offer a serious problem if they are to be maintained and preserved from early destruction.

Many important defensive phases should be borne in mind during the building of an air base. These include particularly the dispersion of vital establishments, the camouflage of landing surfaces and buildings and the preservation of trees and other natural camouflage in the vicinity.

Airdrome and air base defense may be either passive or active. Passive defense measures include camouflage and dispersion. Active measures include defensive armament, anti-aircraft and machine-gun fire, barrage balloon and fighters.

FOREIGN AIR BASES

Our military leaders have learned much about the requirements for the building of suitable air bases and the necessary measures for their protection from a study of the air operations in Europe. They have learned many tricks in camouflage. Some of the more important airdromes in Germany have, by the ingenious application of paint, papier-mâché structures, theater trees and other methods, been made to look like gardens, villages, orchards—anything but airdromes. Some have reported that there is scarcely an airdrome in Germany which when viewed from the air does not appear to have a highway, a high tension line, or some other obstruction running across it, to deceive the eye of the enemy airman. An ingenious method of airport protection against air infantry and the landing of hostile aircraft was reported in Holland. On some airdromes near-by villages hastily had all their trucks and automobiles commandeered. These were parked at irregular intervals to make the airport unusable by aircraft. This use of trucks and automobiles to destroy a landing area has the great advantage that it is readily cleared on signal and there is no permanent damage to the flying field. The use of movable, dummy, papier-mâché buildings for location on airdromes when not being actually employed in take-off and landing, provides a device borrowed from abroad which is economical, timesaving and readily capable of accomplishment.

The use of steel planks or wire netting for runway surfaces as against telltale concrete strips is another European device which is reported to have worked satisfactorily, particularly in France.

The organization of engineer units supplied with road-building equipment in large quantities which can within the space of a few hours build a new airdrome from virgin terrain, leveling it, rolling it, providing drainage and otherwise making it suitable within a day, is one of the primary defenses against air base destruction. In this same connection, the building of dummy airdromes which are not suitable nor intended for aircraft use, but which from the air have the appearance of an airdrome, is an excellent way to misdirect the enemy's bombardment effort.

An observer back from the early air war in China reported that 1,000 coolies, immediately after a Japanese bombardment of a Chinese airdrome, were put to work filling the bomb craters. With this abundance of man power the airdrome was leveled and repaired and again available for aircraft use within a few hours after each daily attack. The same policy now is employed by the British to repair their landing fields after bombing attacks, with the variation that they have engineer troops stationed nearby to perform the required repairs. Modern construction methods can complete such repairs within 24 hours, although it was generally believed that much more time would be required.

Another important consideration in air base defense is the maintenance of channels of communication, railway lines and highways. Operating air bases require great quantities of supplies and stores, particularly gasoline and explosives. These must be delivered to the airdrome in heavy trucks or by rail. It is vital, therefore, that the highways and railroads leading to an airdrome also be camouflaged as thoroughly as possible and be so constructed that there are no bottlenecks such as bridges which would require much time for repair. Duplicate railway lines and highways should be provided for all major bases. This problem is relieved considerably where water transportation, as well as rail and highway, can be made available.

One airport problem which comes thundering louder than the rest from the air battles overseas requires for solution the provision of multiple flying fields and air bases. Never, our observers tell us, should an air force be committed to the use of a restricted area or a small number of air bases. In the light of this intelligence, the number of civil airports available as temporary bases takes on a special significance. Nearly $100,000,000 was made available to the Civil Aeronautics Authority of the Department of Commerce in 1940 alone for the new airport construction program. One of England's weaknesses lies in the fact that her limited area makes it difficult to multiply airdromes. We in this country would not be so limited. We have far more extensive and better terrain and more opportunity for an adequate airport program than any other nation on earth. This is but another of our natural American advantages which we must not lose sight of and which our national leaders must be wise enough to utilize to the limit.

Chapter Four

ORGANIZATION OF AN AIR FORCE

"What is needed now, I think, more than at any time in our history—certainly more than at any time since the turn of the century, is an examination, or rather, a re-examination of our military policy on national defense on broad general lines, and its relation to the foreign policy which it is intended to support. This cannot be done by considerations by separate committees of Army and Navy. It must be done by a select joint committee of both Houses, to give a full examination in the face of situations now arising in the world."

—George Fielding Eliot

ORGANIZATION is the governmental structure for management. It is the instrument through which the leader expresses his will and exercises his control.

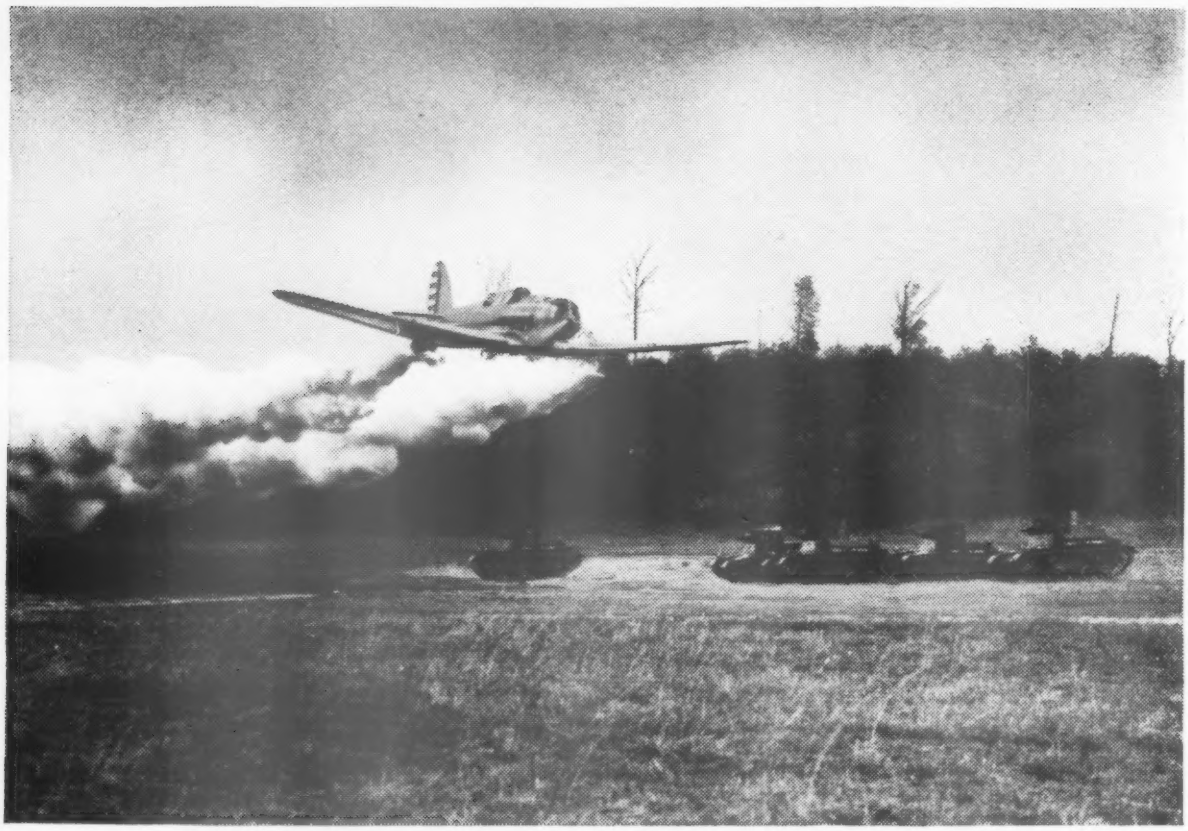
An air force, like the older military organizations, the Army and Navy, requires a definite organization. Unlike the older branches, however, there is no ancient historical precedent for our air arm to follow. Air forces here and abroad have suffered from that lack of precedent and example. For that reason air force organizations in all the leading nations of the world have been in an almost constant state of flux since the first World War.

In our own country this instability in organization has been more marked than elsewhere. In the last 21 years there have been 19 separate investigations of the Army Air Forces by direction of the Chief Executive, of the Congress, or of War Department agencies.

The initial decision in determining the organization of an air force is whether or not it shall be given parity with the Army and Navy or whether it shall be treated as an adjunct, subordinate branch or subdivision in these older institutions.

At present, military aviation is an arm or branch in the Army, as are the infantry, cavalry, field artillery and other combat branches. In the Navy, aviation is also a subdivision of, but an integral part of the fleet. There has been a persistent movement since the first World War to alter these organizations. A bill has been presented to each succeeding Congress since 1924 to authorize what is called a separate air force—an establishment composed of the aviation branches of the Army and Navy, but under the direct control of neither and operating as a separate military agency. Under this plan, instead of officers of Cabinet rank, called the Secretary of War and the Secretary of Navy, there would be a Secretary for National Defense with coequal subsecretaries for Army, Navy and Air.

The leaders in the Army and Navy are one in the thought that military aviation is a new weapon of importance. They acknowledge that any army, to be successful in the field of



Certain branches of the Army Air Forces receive training in the laying of smoke screens. The old attack plane (A-17A above) was used by the Army. Light bombers now will undertake this assignment.

battle, must have its own aviation to protect the troops on the ground and to serve as winged artillery. The Navy calls its aviation the eyes of the fleet and most naval leaders are willing to admit that no naval action can be successful without air superiority in the theater of naval operations.

The proponents of the *status quo* feel that there must be unity of command in any theater and that all weapons must be subordinate to that commander, under his complete control and direction. They point out that there has seldom been in the past a long and sustained operation requiring the joint action in a limited theater of both the Army and Navy. On the other hand, any action involving either the Army or the Navy operating separately is certain to have its air phase. Therefore, they maintain, there is not the same reason for separating the air force which caused the early national fathers to separate the Army and the Navy.

It is contended that the Army and Navy, being old and well-established institutions with large, experienced and capable staffs and trained technical experts, are better able to develop this new weapon than any other agency which must necessarily include in its ranks relatively young men and which would at first be merely an experimental organization. They hold, also, that since an air force requires the support and co-operation of supply services—Ordnance, Signal Corps, Quartermaster, Medical, Chemical and Engineer—and since each of the services now well established can supply the needs of the air arm, in the interest of efficiency the flying branches should remain under the old establishments.

The leaders in the older services profess a fear that if the air force were made coequal with the Army and Navy, the two older services would not receive the efficient air co-operation essential to the success of either. As a final argument, both the Army and Navy point with pride to the air establishments each has built up as positive evidence of their respective abilities to create and control military and naval aviation.

The advocates of a separate air force have based their declarations for the most part on the following contentions: They say that the other leading nations of the world have gone to the separate air force idea. They point to Great Britain, with its Air Ministry and Royal Air Force coequal with the Army and Navy. They point to the separate air force in Germany. They contend that military aviation should be under the control, leadership and management of flying men, men with long military aviation background and experience. They state that our present War Department organization is conducive to delay and indecision.

The military leaders of the separate air force idea contend that every nation hard pressed in warfare eventually has been forced to go to the separate air force and that it is more efficient to work out this organization in peacetime than it is under the stress and strain of conflict. As evidence that flying men are submerged, they point to the fact that until recently there were but two general officers who were ex-airmen, of the total of more than 125. They contend that but a limited number of air officers are detailed to the General Staff and those are fairly junior in rank. "Flying leaders for flying fighters" is their battle cry.

During the past 20 years there have been schools of military thought who were not willing to go so far as to advocate a separate air force, but who believed that the military air establishment should be removed from the General Staff of the Army and set up as an independent corps on much the same status as the Marine Corps is organized in the Navy. They

would have an Assistant Secretary of War for Air and an air staff and remove the air branch from the Chief of Staff and the General Staff of the Army.

As a result of the recommendations of the Morrow Board, an Act of Congress approved on July 2, 1926, provided for an Assistant Secretary of War who was to be charged with the direction of military aviation. The Honorable F. Trubee Davison was appointed Assistant Secretary of War for this assignment and remained on that duty from 1926 to 1932. From 1932 to date, 1940, although the original act still authorizes an additional Assistant Secretary of War, the office has not been filled.

In the fall of 1940 a Deputy Chief of Staff for Air was created and made the direct advisor of the Chief of Staff for the control and direction of aviation matters. At the same time it was announced that the General Headquarters Air Force, comprising the combat side of military aviation, would be separated from the control and direction of the Chief of Air Corps and assigned to the Commanding General, General Headquarters.

ARMY AIR FORCES ORGANIZATION

In brief outline the channel of command runs as follows: from the President to the Secretary of War; from the Secretary of War through the Assistant Secretary for Air to the Chief of Staff of the Army. Here control divides. The channel may pass from the Secretary of War to the Chief of Air Forces or from the Chief of Staff to him, thence to the Air Force Commanders and the Commanding Generals of the Overseas Departments. These exercise their control through wing, group, and squadron commanders in that order. From the Chief of Air Forces, on the supply, pilot and mechanic training, and experimental side control passes to the Chief of Air Corps, to the Assistant Chief for Matériel, who is the Chief of the Matériel Division, on supply matters and to the Commanding Generals of the four training centers on the pilot and mechanic training side. They, in turn, exercise their direction and control through training school and air base commanders.

THE CHIEF OF AIR CORPS

The Chief of Air Corps formerly headed the Army Air Corps, which had under its control all military aviation matters. Under the most recent organization, the Chief of Air Corps is in charge of aviation supply, procurement, pilot and mechanic instruction and experimental development. He is assisted in the performance of these functions by three Assistant Chiefs of Air Corps, one who heads the Planning Branch, another who is Chief of the Matériel Division and a third who is Chief of Training and Operations.

The Chief of Air Corps exercises his supervision over aviation matters through an organization in his office composed of nine major divisions and operated by a personnel of about 150 officers and 350 civilian employees. Under the old organization his staff was organized on the theory that the Air Corps, unlike the infantry, cavalry and other branches, was both a supply and combat branch. The Combat Commander is now charged directly with training and operating responsibility for the 54 combat groups within the United States.

The Chief of Air Corps as the head of a supply and training establishment has a task of great responsibility, as is evidenced by the fact that he was charged with the expenditure of nearly $2,000,000,000 in the Air Corps expansion inaugurated during the year following July 1, 1939. He has three major responsibilities and functions: experimentation and research, supply and procurement. In the performance of this task he controls a vast organization, the Matériel Division, one of the finest aviation experimental plants in the world. It has an organization of about 200 officers and 6,000 civilian employees. The Matériel Division, under the direction of the Chief of Air Corps, carries out two vital functions, aviation experimentation, and procurement and supply. It is the function of the experimental department to do the necessary research, to make certain that our airplanes and aviation weapons and accessories are, if possible, superior to those in the other air forces of the world.

Aviation supply and maintenance, although controlled at the Matériel Division, is carried out by means of five territorial depots in the United States and three in the foreign departments, Puerto Rico, Panama and Hawaii, with a minor depot in the Philippine Islands. It is the responsibility of these sup-

Materiel Division research laboratories developed this extra instrument panel and movie camera installation, which photographs plane's instruments during test flight, for later study by engineers.

ply agencies to insure the complete and continuous equipment of all aviation units in the essential Air Corps items and other War Department items peculiar to them. The Ordnance Department, for example, is charged with the supply of guns and ammunition to the Air Corps. The Signal Corps supplies the communications equipment, and the Quartermaster Corps supplies the personal equipment of the soldier and provides for his shelter and feeding. The Medical Department of the Army provides for the hospitalization and the care of the sick and wounded. The Chemical Warfare Service is charged with the supply of chemical items and with chemical instruction and protective equipment to the Air Corps.

The Chief of Air Corps, in exercising his supervision over the training establishment, has an Assistant Chief of Air Corps charged directly with the efficiency of our schools. He, in turn, directs the operation of four training agencies—three Air Corps pilot training centers and one mechanics training school. Each of these establishments is headed by a brigadier general of the Air Corps.

The Chief of the Air Corps is a member of the Joint Aeronautical Board to insure co-operation between the air establishments of the Army and the Navy. He is also the advisor to the War Department and the General Staff on air matters affecting pilot training, mechanic's training, experimentation and research, and supply, where there is joint interest with any other Government bureau.

In carrying out his procurement functions, the Chief of Air Corps signs all contracts for the purchase of airplanes, engines, spare parts, fuel and lubricants, and other aviation items. Under the law the Assistant Secretary of War is charged with supervision of procurement for the Army. The Chief of Air Corps works directly under him in the performance of his procurement and production functions.

The Chief of Air Corps also is charged with the preparation of budget estimates and with the defense of these estimates before the War Department Budget Advisory Committee, the Bureau of the Budget and Congressional committees.

THE COMMANDING GENERAL, COMBAT COMMAND

In 1934 the War Department organized the combat units in military aviation into a separate command called the General Headquarters Air Force. Initially it was separated from the Air Corps and its commander reported directly to the Chief of Staff. In 1939, the GHQ Air Force was placed under the Chief of Air Corps. In November, 1940, the Commanding General, GHQ Air Force, was elevated to the rank of lieutenant general, a grade formerly held only by the four field army commanders and the department commanders in Panama and Hawaii. The Commanding General has been added to the Air Forces Air Council, the Air Forces Headquarters Air Force; and has a separate section now called the Combat Command.

The creation of the Combat Command has proved a wise and forward-looking step.

As pointed out earlier, there is a dearth of precedent in military history to guide the formulation of air combat organization and training and the War Department evidently realized that much experimentation and maneuver experience was required in order definitely to settle upon the most efficient organization and combat training methods for military air units. The GHQ Air Force, for four years under the able leadership of Maj. Gen. Frank M. Andrews, its first commander, eminently discharged the responsibilities and carried out the functions which had been visualized for this new establishment. Lieut. Gen. Delos C. Emmons, chief of the Combat Command, is proving those first steps were correct.

Initially the GHQ Air Force was composed of five wings. In the Air Corps expansion inaugurated July 1, 1939, and with the increase of the Air Corps from 60 to 288 squadrons, there have now been activated 22 wings.

With the increase of the Air Corps from 1,800 officers and 18,000 men to 12,000 officers and 160,000 men, as provided for in current expansions, and with the increase from five to 22 wings, it was found necessary to divide the United States into four air forces, each of these air forces to be headed by a commanding general of the rank of major general. The War Department extended this organization in the summer of 1941 and placed all air combat functions in the Combat Command, a part of the new Air Forces. The territorial limits of these four air forces are indicated on a map in this book.

THE WING

A wing is a tactical air unit composed of two or three groups. There are two types of wings, composite and heterogeneous. The composite wing will have one or two pursuit groups and one bombardment group. The heterogeneous wing will have two or three pursuit groups or two or three bombardment groups. The present trend is toward the latter, since it is believed to be more efficient tactically to have only one type of combat aviation in one command of that size.

The wing corresponds to the brigade as a tactical subdivision for the ground arms. It is envisaged as the largest air fighting unit which one commander can efficiently control and directly supervise. It is a tactical command as differentiated from an administrative command. The wing commander supervises the training and tactical operations of his groups and is not concerned primarily with administration and supply. These latter functions are performed by air base groups which are housed in peacetime on air bases with the tactical groups and which perform their administrative, supply and housekeeping functions for them. The location of the 22 groups and their types are indicated by the map on the front end sheet.

THE GROUP

The Army Air Forces group is normally composed of three squadrons. It was conceived as the largest air unit which one leader can efficiently control in the air. Tactical groups are for the most part heterogeneous, in that their three component squadrons will be of the same tactical type, fighter or bombardment. The group corresponds to the regiment. It is both a tactical and an administrative unit. Its commander is generally of the rank of colonel or lieutenant colonel and is always an experienced flying officer, capable of leading his unit in air combat as compared to one who directs his command from the ground. The bombardment group, for example, is composed of 60 officers and 800 men. It has attached small units of Ordnance, Signal and Medical troops for service in the field. In addition, forward echelons of the air base unit perform its housekeeping and airdrome functions when it is in the theater of operation. While stationed at a permanent air base, the air base group for that station performs these service functions for the combat group.

THE SQUADRON

The squadron is the air unit corresponding to the battalion in the ground arms. It is commanded by a major and is the basic flying combat unit. Squadrons of various types have different composition; a fighter squadron is composed of 28 officers and 150 men and has for equipment 28 planes, while a bomber squadron has 21 officers, 180 men and 13 planes. The squadron is deemed essential, as is the battalion in the infantry, in order to have a unit sufficiently small in size to receive personal supervision, direction and control of one experienced officer and in order to provide for detailed training and first-hand direction of supply, discipline and combat methods. Squadron commanders are always flying officers of long experience and are selected for executive ability in the supervision of training and combat leadership. There are six types of combat squadrons with slightly different organizations and personnel strength, dependent upon the type of aircraft they fly. These are transport, fighter, light, medium and heavy bombardment and reconnaissance.

THE AIR DEFENSE COMMAND

In 1939 the War Department authorized a new air organization called the Air Defense Command, composed of two groups of pursuit aviation, a regiment of antiaircraft artillery

and a Signal component for operation of the warning service. The initial experimental organization was designed to work out an air defense organization with suitable equipment and to develop methods for the protection of vital areas from attacking bombers. The headquarters of the first of those new commands is established at Mitchel Field, Long Island, N. Y. It has been engaged since inception in determination of the proper organization and the most efficient methods of defending the northeastern section of the United States. The Air Defense Command is not original in our Army. The necessity for it has been demonstrated time and again in several of the countries in Europe during recent air operations.

Several large-scale maneuvers, the latest being those of the first Army in the summer of 1940, have been employed to perfect the organization of the Air Defense Command. As a result, other Air Defense Commands will be organized, taking full advantage of European experience in actual combat operations and making such adjustments as our situation requires. The War Department has followed the precedent abroad and placed an air general as the commander of the Air Defense Command.

CO-OPERATIVE AVIATION

In its broadest sense the air forces of the United States include all military aviation of every character. In addition to the air units in the regular Army, there are naval aviation and civil air components, the National Guard and the Organized Reserve.

To insure proper co-ordination and co-operation between the air branches of the Army and the Navy there is a Joint Board and an Aeronautical Board. The Joint Board formulates, for submission to the Secretary of War and the Secretary of Navy, joint plans for the operation of task forces, comprising both military and naval units. The Aeronautical Board is charged specifically with the co-ordination of the air activities of the two arms, particularly in the experimentation, development and procurement side for aircraft and their accessories. It also may advise the Joint Board on tactical joint operations.

The air arm of the National Guard is composed of 22 squadrons active and seven additional authorized but not yet organized. The National Guard squadrons are observation units designed to supply the reconnaissance requirements for the National Guard Divisions. They are organized and equipped on the same basis as the observation squadrons in the regular Army.

While the National Guard has heretofore had only observation squadrons, recently, with a view to broadening the scope of their operations, instructions have been issued to train certain National Guard flyers in pursuit units. Perhaps if the experiment proves to be a success, early formation of National Guard squadrons of that type may result.

The Organized Reserve contains about 5,000 flyers, Reserve officers organized into squadrons and other units on paper only. They have neither enlisted personnel nor airplanes. The original conception of the reserves was to provide personnel on Mobilization Day to be called to the regular Army squadrons to raise them from peace strength to war strength and to supply the initial pilot losses during the first 90 days of combat. At present there are more than 3,000 of these Reserve flyers on active duty. They comprise the majority of the pilots in many of our combat squadrons. This picture has changed somewhat during our present emergency, as we have speeded up our training schools and now have an annual output of pilots far in excess of the total number of Reserve officers on our rolls a year ago.

Under our system, graduates of Air Corps training centers are commissioned as second lieutenants in the Air Corps Reserve and called to active duty for additional organizational training. In order that the Reserve flyers who have returned to a civil status may maintain their flying proficiency, Reserve units are maintained at or near the principal centers of population. These units contain a regular Army instructor and a group of 20 to 30 Army Air Corps mechanics who maintain a number of advanced training type airplanes. Reserve officers utilize this equipment in spare time. Each Reserve officer flyer not on extended active duty may be given a period of 14 days active duty annually if he applies for such assignment. The Reserve aviation component is indispensable, as there are only about 2,000 regular Army flyers and the balance of the 12,000 necessary to furnish flying combat crews for the new Air Forces of 288 squadrons will come from the Reserves.

Reserve officers who are fairly recent graduates of the Army flying school are assigned to fighter and bombardment units. The older graduates are valuable in Air Corps transport groups. Pilots and copilots on our airlines would be very valuable for such service without any additional training.

The Army Air Forces has 30 observation squadrons assigned as the aviation for the Army divisions. These squadrons are not part of the Combat Command, but form what is termed co-operative aviation. The creation and organization of these units is a function of the Chief of Air Corps. He also is charged with the provision of their airplanes and flying equipment. The training of these air units is a function of division and corps commanders to whom they are assigned. These, with our 22 National Guard squadrons, make a total of 52 squadrons or a force of about 1,500 officers, 7,500 men and 750 airplanes available to the Army's corps and divisions for observation and command purposes. All our military leaders are now agreed that this co-operative aviation is essential to the proper training, tactical operations, maneuvers and combat in warfare of the ground arms.

It is not unlikely that military organization will see a decided change in this regard in the near future, with the provision of all types of aviation save heavy bombardment for close co-operation with the ground forces. Since military aviation is a weapon of great mobility and has far-reaching effects, it is probable that the fighter and bombardment units will always be maintained under the control of the Combat Command and be detached to the corps and armies for co-operative training during maneuver periods, and attached to ground units in actual warfare for a single operation only.

A review of the German campaign in Poland is convincing as to the necessity that mechanized and motorized units particularly will be required in warfare to co-operate closely with air organizations to secure the maximum efficiency and effectiveness in the accomplishment of their joint mission.

AIR ORGANIZATION ABROAD

Some features of the organization of the air element of the military establishments now engaged in conflict in Europe are worthy of note. There is a tendency to group fighter aviation into a fighter command and to group bombardment aviation into one large unit called the bomber command. This separation undoubtedly is caused by the fact that fighters of the interceptor and night pursuit types usually form a defensive organization which operate in a limited theater at home, whereas the bomber element is offensive in character and is engaged in distant missions against enemy objectives. There has been no change in our organization to date along these lines.

In both the British and German military organizations, antiaircraft artillery is an integral part of the air force. In this country the antiaircraft artillery is retained under the coast artillery. It has, however, been detailed, as in the case of the Air Defense Command, in some cases to work in close cooperation with fighter aviation. Some contend that there would be closer co-operation and greater efficiency in our training if the antiaircraft artillery were a part of the Air Forces. This organization works out particularly well in Great Britain and has provided a remarkably efficient defense for Germany. Others feel that the principle of detachment is sufficient and that our organization, where the artillery and the aviation are separate establishments and not under common command, is satisfactory for our purpose. Then again,

our geographic situation is so entirely different from that of European countries, where England and Germany are looking right down each other's throats.

Air Defense Commands and particularly warning services have had a much more thorough development abroad than in this country. Warning nets were established, and detection devices set up. Civil observers were organized and used wherever possible. These have worked well and have been essential supplements to air defense. Abroad there has been an organization of home defense units, to include anti-parachute troop units, air-raid precautions units and organizations charged with supervision over air-raid shelters, operation of air-raid warning equipment and particularly with the removal of debris as a result of enemy bombardment. Little has been done in this country in organizations of this character.

In the lower echelons there is little difference between any of the combat units of air arms in different countries. The organization of the squadrons, groups and wings in the combatant nations abroad is quite similar to our own. The German air force, particularly, however, has gone much farther in the development of higher organizations, as is understandable in view of the tremendous size of their air force. They have created air divisions and air fleets, combinations of wings such as ours grouped under a single command, apparently for more effective training and operational control. Any further expansion of our Air Forces will undoubtedly call for units similar to their air divisions and air fleets.

As nearly as can be ascertained, it seems that there is a much smaller percentage of staff overhead in the air organizations in England, and particularly in Germany, than in this country. The staff officer is a noncombatant. In order to be suitable for the staff he must be an officer of experience. Any saving, therefore, which can be made in staff personnel, can be used to augment the fighting forces. The air forces abroad have been subjected to the supreme test, that of air combat. If they have determined that they can operate efficiently with reduced staffs, it is a determination which we may well employ.

Another lesson from air organizations engaged in the European conflict is in the creation of task forces. When Germany determined to go into Norway, the staff of the supreme command determined what proportion of air, ground and sea elements should comprise this expeditionary force. It then designated a commander and thereafter there was complete unity of command and no interference from the three arms of the service thus combined. Here is a lesson which we must study well; it may supply the answer to the requirement for unity of command in many military situations which may develop incident to hemisphere defense.

It appears that despite the great pressure which has been placed on the air arms of the countries now in battle, each of them is maintaining a highly efficient, versatile, strong aviation experimental staff in order to insure that airplanes, engines and their equipment of the most advanced type are always ready for production. The wartime tendency to put in quantity production items which are then available and to close the laboratories as useless appendages must be resorted to only when quantity production is of vital importance. Even then, plans must be made to provide for reopening the engineering sections at the earliest opportunity.

Superiority of aircraft performance in combat is essential for us if we are to win.

The organization and training of the civil populace will be an important factor in maintaining a stouthearted morale under the hail of enemy bombs. Much can be learned from the experiences of the present combatant nations in this regard.

One of the most important peacetime functions of the military establishment is the perfection of organization along sound lines. This applies to the air arm as to the other branches of the military establishment. It is the essence of proper national defense.

Chapter Five

AIR TACTICS

"Here, then, is the striking contrast between the German military system and all other systems: the Germans prepared for this war, the British (and the Americans) prepared for no war, the French prepared for the last war. The German tactics risk much to gain much quickly; the French risk little to gain little surely; the Germans use the tactics of speed, the French the tactics of time. It was these two fundamentally varying systems that clashed in Homeric struggle last week."

—Hanson Baldwin, *New York Times*, September, 1939

AIR tactics may be defined as the employment of air units in battle. The tactician is frequently confused with the strategist. Tactics come into play only after strategy has run its course. The play, be it comedy or tragedy, is directed by the tacticians, the soldiers are the players.

When war comes, the first units to be joined in battle will be the air units. It was so in Spain, China, Poland, Norway, Holland, France and now in the Battle of Britain.

The student and the practitioner of air tactics is not handicapped by centuries of illustrious lore as are those of the ground troops. His tactics are still in the formative period as, indeed, are his weapons. The air fighter today really is writing the first pages in the first chapter of aerial warfare, for airplanes during the first World War were so little developed that no definite principles could be permanently set.

Tactics are limited and proscribed somewhat by natural characteristics. For land armies and navies this has always been an important consideration. Seasonal, daily, and irregular habits of nature also effect air tactics. In the first World War and again in this one, the little air fighter hides in the clouds. It escapes in the overcast. It falls out of the blinding sun on its unsuspecting prey. Sodden airdromes can ground an air force.

Geographical considerations also have had a tremendous effect on battle lines and battlefields. Geographical forms—mountains, rivers, land and sea, do not influence to the same delimiting extent the joining of air battles. Geographical considerations do, however, tremendously affect air strategy and play a considerable part in the tactics of air warfare. How many times have we heard the broad expanses of the Pacific and the Atlantic described as our best barriers? Much have we heard about the range of aircraft as the determining factor in permitting widely separated opponents to come to grips in air conflict.

National traits and characteristics have had their influence on land and sea battles. These, too, will influence air tactics as well. It is now generally believed that a people like the Germans or those of the United States, who have had considerable mechanical background, who have grown up from childhood in close contact with turning wheels, moving levers and motive power, will the more readily adapt themselves to sky fighting. It is undoubtedly true that the people of the Western world and of Europe come more naturally by the new art of human flight than the Orientals or those who have been touched less lightly by the machine age and modern civilization, as for example the Ethiopians.

Methods of fighting—tactics—have from the earliest times been greatly influenced by leadership and by weapons. Bold, aggressive, alert, intelligent leadership has generally won on the battlefield. The forces best equipped with powerful weapons in greatest quantity and those most familiar with the employment of the weapons of most modern type, usually also have conquered. The latest and most striking example is the success of the German Panzer Divisions.

Air operations are of two major types, independent air force operations and co-operative, air-ground, or air-naval operations.

CO-OPERATIVE AIR MISSIONS

A great many military leaders were rather reluctant to accept the air weapon as other than an agency to affect the land or naval battle. It was not until 1934 that our own Army, in

recognition of independent air force operations, established the GHQ Air Force. Co-operative aviation concerns itself with the winning of a battle, independent air force operations with the winning of a war. There is always a grave danger that a leader, seeing only the battlefield, will win the battle but lose the war.

OBSERVATION AVIATION

There are many types of observation missions. The observer may be sent forth to report on the course of a local encounter. He may be sent to discover the movement of ammunition supply on highways. He may go to photograph ammunition and supply dumps, or to gather evidence indicating a flank movement of an attacking force in a particular area.

A brief description of a typical observation mission will indicate how the air observation team works. Soldiers fear a turning movement on their flank. The general directs the G-2 subdivision of his staff to obtain immediate information which would indicate enemy intent. The G-2 or Intelligence Staff agent telephones the observation airdrome 25 or 30 miles to the rear and calls for a reconnaissance flight at a given hour over a given sector.

Observation aviation is now an integral and essential part of the forces and equipment of land armies. The air observer not only looks down on the maelstrom from above, but he brings home the unmistakable evidence on photographic plates.

There was a time when soldiers could be hidden in the woods. When the green leaves of the forest made the best camouflage and cover. Color photography has changed all that.

Within a few minutes the twin engines of the fast, light bomber used for observation work are turning over, the camera has been loaded, the crew—pilot, photographer and gunners are aboard the plane. The plane goes by the most direct route to the area indicated on the map and, at an altitude which will avoid small caliber machine-gun and rifle fire, taking advantage of whatever cover the clouds afford, cruises throughout every part of the terrain in question. The observer records the numbers and character of troops observed, military movements on highways, types of trucks, character of cargo, volume of traffic; the great nine-lens camera grinds away steadily during the whole period, making a complete photographic map of the whole area. Gunners are at their stations to greet with machine-gun fire enemy fighters.

The mission completed to the satisfaction of the observer, he notifies the pilot by inter-phone and a straight course at maximum speed is set for the home airdrome. The principal safety of the observation plane lies in its speed and the quickness with which it can accomplish its missions. Immediately upon landing the observer will render his report to headquarters by telephone and in writing.

The airplane scarcely will have stopped rolling when the camera is pulled from the ship and hurried to the photographic darkroom. In less than an hour maps and plans at headquarters will be changed to conform to the latest information and the general, secure in the knowledge that he knows what the enemy is about, will lay his plans accordingly.

In particularly critical times the observer will report by radio as he flies and observes. As a result of new quick-method photographic equipment aboard observation aircraft, developed prints can be dropped at headquarte to save the half-hour delay in returning them to airdrome and dispatching them overland.

ARTILLERY RÉGLAGE

Observation aviation was used before the first World War to direct artillery fire, to report on the location of hits and help the artilleryman to get on his target. The airman is particularly valuable to the longe-range artilleryman who has no other method for observing the location and effect of the high-explosive shells he delivers. The aerial spotting of big guns is a worth-while job for the trained air observer.

COMMAND MISSIONS

Some military observers feel that the Germans employed a new type of aviation in the Polish campaign. Small, light, slow landing planes were used by commanders of divisions and corps to get them well forward with their troops and to observe the progress of the ground battle lines. It is necessary to have a plane of this type which can land in city streets or on small patches of ground and which can land so slowly as not to be disturbed by rough terrain, plowed fields, small shrubs or crops. The Germans developed the Fieschler-Storck for such missions and were almost able to obtain the landing characteristics of the helicopter. It had not been realized in other countries that this was a military weapon. A considerable number of these planes were used in Poland for the execution of command missions, for intimate intelligence work by the commander himself and by the senior staff members.

The most modern thought in our Army holds that there is always some loss in the second-hand transfer of information. There is some coloration by the observer or there is the likelihood that some small detail will be overlooked which would be interpreted in an important way by the commander could he have seen it himself. This advent of the airplane particularly adapted to command missions is an attempt to solve this problem.

It was learned before the Battle of France had run its brief course that the old type observation airplane, a slow, lumbering craft, could not exist on the battlefield. Fast-flying pursuit planes were assigned with no other task than to clear the area over the battlefield of the hostile observation aircraft.

In the last war observation balloons played an important part in the collection of enemy intelligence in nearby front lines. Information received from the battlefields of Europe during 1939 indicates that the observation balloon has almost entirely passed from the scene. They can be destroyed with such ease and such rapidity by modern fighter aircraft with their six or eight machine guns that it is uneconomical to replace them and their trained crews at the rate at which they can be shot down.

It now appears that the observation airplane must have great speed. To be entirely effective it must carry considerable equipment and a crew capable of defending it and of recording the information desired. This calls for a plane of the light bomber type. To avoid multiplicity of types insofar as possible, planes of this category are being pressed into observation service.

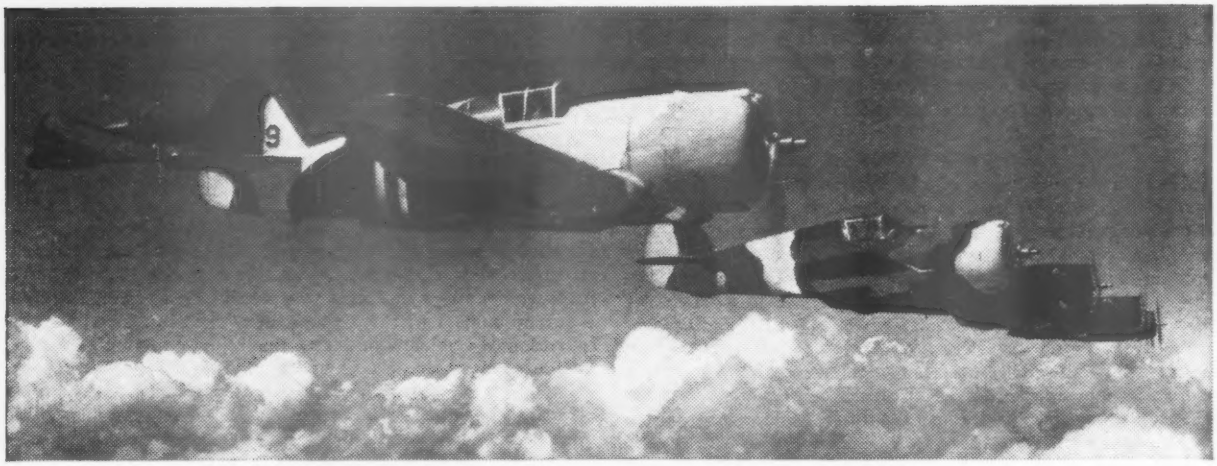
CO-OPERATION WITH MECHANIZED FORCES

Another type of co-operative mission which flowered into full bloom in the German-Polish campaign in September, 1939, is the co-operation between the light bomber and the Panzer Division. The tactics in Poland were duplicated in France on a larger scale.

Some years ago our military school men drew the conclusion that tanks and mechanized forces were too vulnerable to artillery and infantry automatic weapons to be used in masses in warfare. The success of the German Panzer Divisions made many red faces among the instructors in tactics in our own schools.

Mechanized forces are vulnerable. They need the light or dive bomber ready at hand at their call to dislodge the road block, the strong points, the concealed automatic weapons, or the artillery behind barriers which could stop them and force them to dismount and deploy. It is reported that time and again when it appeared that a long, mechanized column would be forced to stop, dismount from its vehicles and fight a land battle in order to clear its path on the highway, its commander, using the radio, called for help from his teammate on the airdrome and almost instantly dive bombers were pouring small bombs and heavy machine-gun fire into the personnel and matériel at the point of obstruction.

Many followers of the campaign in France and Belgium were stunned and dumbfounded when the Stuka-Panzer duet



Our pre-war Army pursuits were almost helpless on today's standards. These Curtiss P-36A's carried only two machine guns and an elaborate but useless camouflage design. Newer P-40's carry at least six guns.

turned eastward from the coast toward Sedan and stuck out a long thin finger toward Calais and Dunkerque. It seemed impossible that even the boldest and ablest military leaders could hope for success in such a maneuver. Again the power of the bomber and its co-operative effect with motorized forces had been overlooked.

One decisive battle was fought in the first World War which pointed clearly to the success of the dive bombers in the fall of 1939 on the battlefields of France and Poland. General Allenby in the Palestine campaign in 1918 routed and cut to pieces a large Turkish army, employing attack aviation as it was then called—light bombers armed with light bombs and machine guns. The British commander had at his disposal about 50 single-engine light bombers of the DH type. They fell upon the Turkish forces while passing through mountain defiles and completely annihilated or routed an entire army of more than 100,000 men. This battle, although not widely advertised because of the more extensive and headlined engagements in France at that time, was known to the military leaders of all the world for 20 years succeeding that war and prior to 1939. And yet apparently it stirred nobody but the Germans to a full realization that a new concept for employment of airplanes had come to land warfare.

The Stuka bomber, the type which the Germans used most extensively in their dive bombing and in co-operating with motorized, mechanized forces, did not come off entirely unharmed. Their low bombing and low attack methods subjected them to a withering fire from ground automatic weapons. The British have not been slow to learn that lesson. Their expeditionary force learned it in the escape out of Dunkerque. It is hinted by more recent operations that the Germans have learned the lesson too. They may be compelled to abandon dive bombing—a type of aircraft employment never enthusiastically received by our own leading airmen—in favor of low altitude horizontal bombing, where bombs are delivered from an altitude beyond the range of automatic small-caliber weapons.

Be that as it may, the power of the co-operation of light, fast tanks, scout cars and other mechanized weapons and light bombers remains as the principal tactical lesson to draw from the land fighting in most modern times.

PARACHUTE TROOPS AND AIR INFANTRY

Norway and Holland were the battle grounds for the first extensive use of air infantry and parachute troops. The air infantryman is merely an infantry solder transported in aircraft and set down in a remarkably brief time at an unexpected place where his presence and power will greatly embarrass his enemy.

Parachute troops are merely infantrymen dropped from an airplane by the use of parachutes. They are dropped either because the airplane cannot land or because its landing would disclose the operation. Once he is on the ground, the foot soldier discards or destroys his parachute and becomes an infantryman employing infantry tactics.

Tactically the great value of both air infantry and parachute troops in a modern battle is the surprise factor. There are many situations in the battles of the past when a limited number of men at a critical point would have been decisive. There will be many such situations in future engagements. The general who perceives this and appreciates his new power to bring pressure on his opponent will go a long way toward winning the battle.

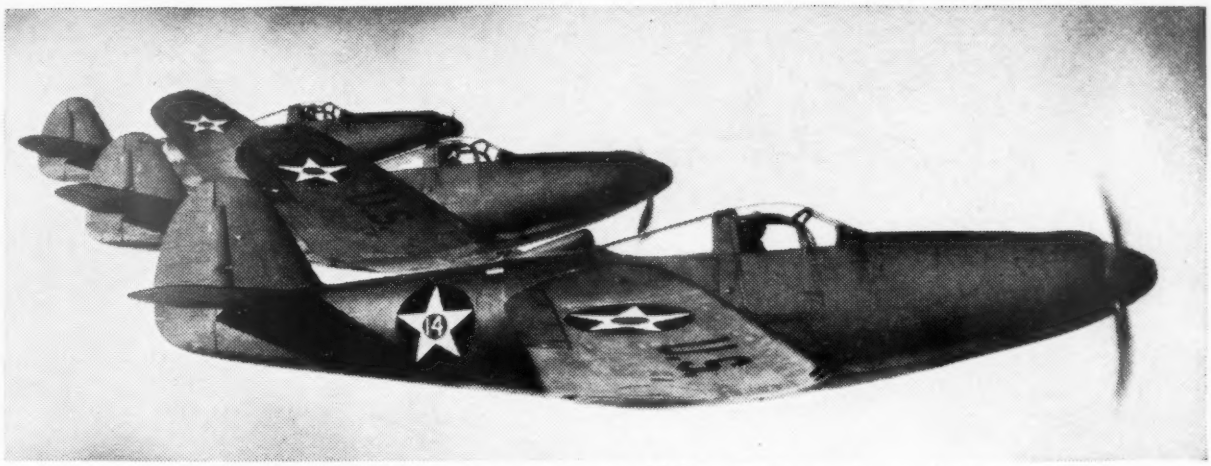
A few men dropped in the vicinity of large ammunition stores in the darkness can easily destroy them. A few men with machine guns dropped near highways, particularly at bridges or in mountain passes, can rout a larger force, keep bodies of troops from crossing the obstacle, prevent the bridges from being destroyed, or can lead the enemy to believe a much greater force is present in his rear. Parachute troops also may be used as the leaders and organizers of dissident elements in an enemy country, sympathizers of the opposing country. This type of operation was designated in the Spanish Civil War with its now famous or infamous title—"Fifth Column."

AIR TRANSPORT

Aside from the transport of troops in limited numbers or in a particular situation, described above as air infantry, it is not unlikely that considerable numbers of men may be transported over great distances and that their equipment, even their heavy equipment and heavy artillery, may in future wars be carried on wings. The outstanding example of the employment of air transport in recent times was its use by General Franco to move an army of 12,000 men from Morocco to Spain. In less than three days, employing a dozen old German transport planes, General Franco transported his crack regiments from Morocco to aid the faltering revolt in Spain. These men carried their machine guns, their impedimenta, everything except their heavy weapons. It is generally believed that this was a decisive factor in the eventual victory for the Nationalists.

Other employment of troop transport occurred in the German occupation of Austria, Czechoslovakia and Norway. In Norway infantrymen were set down at important localities to hold flying fields and key points. Many of the troops which were crossed to Norway from Germany on boats were later supplied in good part by the use of air transport. Wounded were evacuated, ammunition was laid down in isolated points where no other troop transport was available and in other ways land forces were supported in the field by aerial freight carriers.

Medical care in the evacuation of sick and wounded is a considerable factor in maintaining the morale of the fighting man.



The Bell P-39 is the Army's most up-to-date single-engined fighter. It carries several guns and a 37 mm. cannon. All types except training planes are colored dull olive, with light sky-blue under surfaces.

In Ethiopia, for the first time, air transport was used extensively for carrying large numbers of sick and wounded across long stretches of sand and water where other form of transport would have been too slow to save human life. It appears likely that the aerial ambulance will be a definite and integral part of a modern army. Many campaigns which can be envisaged, particularly in carrying out hemisphere defense, would necessitate evacuation of sick and wounded to military hospitals for hundreds of miles over water and jungle.

PURSUIT AVIATION

Another form of co-operative aviation of great value to the land army is the protection of the ground forces from air attack and the prevention of enemy observation aviation gleaning vital information. This is accomplished by the use of pursuit or fighter aviation—a single-seater airplane—equipped with six or eight machine guns and probably a 20 or 37 mm. cannon.

It will be vital for the general on the ground or the admiral on the sea to have the assurance of his airmen that they will sweep the skies above him clear of enemy aviation and maintain that status until the land or sea battle is over. That is an important co-operative mission. It will be accomplished by bringing to that theater, the limited area above the battlefield, sufficient aviation to make it unprofitable or impossible for enemy observation planes and bombers to sneak through.

The classic example occurred at Dunkerque during the evacuation of the British Expeditionary Force. There appeared the perfect target for attack by bombardment aviation. During those four days the British concentrated enough fighter aviation above and in the vicinity of Dunkerque to destroy the enemy bombers which attempted to sweep down on the embattled B.E.F. or denied access into that area to the bombers. The Germans' pursuit airdromes were still in Germany or in Holland and much too far in the rear for them to bring superior fighter aviation into the theater to drive off the British fighters, to regain air superiority.

DANGERS IN AIR CO-OPERATION

There are many mistakes which not only can be made but which are likely to be made by the ground army in the employment of a new weapon. The first of these, by a strange anomaly, may be overanxiety, the employment of this weapon too soon or too extensively. The hard-pressed infantryman will be likely to call for air assistance when his own artillery would be more or equally effective. He knows that the airman can find and see the target. He can see the activity as the airman works against the enemy. It elevates morale.

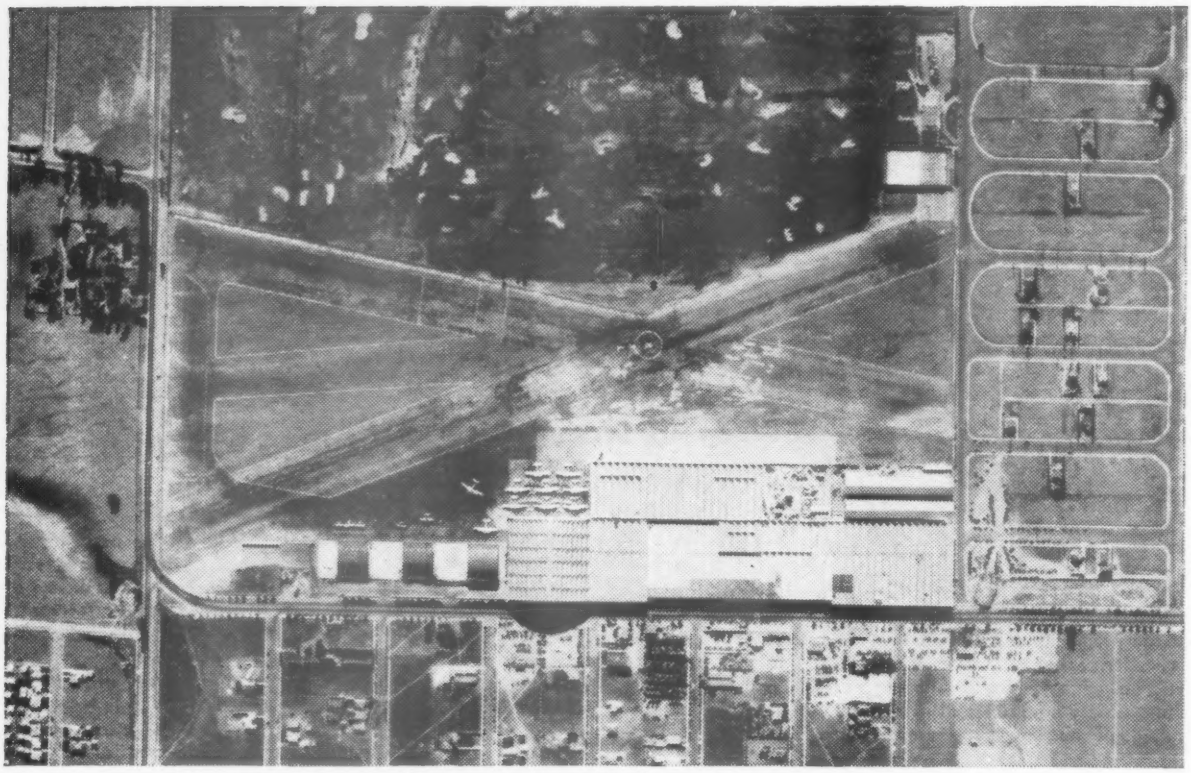
As a matter of fact it will not be surprising if the swing of the pendulum toward the employment of co-operative aviation missions goes too far. Commanders are likely to take it up too enthusiastically. The mission of first priority for our air forces is not co-operative in character. The first priority missions are the destruction of opposing air forces and vital enemy objectives beyond the range or theater of influence of land forces To take all or a good part of the air force and remove it from these higher priority missions to missions co-operative in character would be a dangerous error.

There is also a likelihood that the infantry, once accustomed to air transport, no longer will want to walk or ride to battles. The airplane is an expensive mode of transportation for the foot soldier. It is a weapon of opportunity only and must be visualized as such only.

Above all, our military leaders, observing the success of a particular operation, like the Polish campaign, where dive bombing was used almost to the exclusion of other methods, must not jump to the hasty conclusion that dive bombing is the most profitable method of bombing attack. Several reasons may have motivated the Germans in the use of dive bombing. They may have had advance information that their opponents were not trained in ground strafing of aircraft. They may have been doubtful of the ability of their own untrained or partially trained airmen to do effective bombing at high altitudes. They may have been ignorant of the casualties which would be inflicted upon dive bombers by trained infantrymen with automatic weapons. Whatever the reason, the success they had obtained in Poland led them to use the same operation in France. There, in the early days, it was equally successful. Toward the end of the campaign, particularly against the British in and around Dunkerque, it became evident that it was not the completely invulnerable type of attack it was first believed. It appears that the Germans themselves now are revamping their methods of air attack on troops.

INDEPENDENT AIR FORCE OPERATIONS

We have said that the first phase in the war will be the air phase. This air phase will consist of independent air force operations. Long before the battle lines have been joined on land or at sea, the air forces of the combatant nations will be engaged. Their first job will be to destroy each other. Their second task will be to influence as powerfully as they may the ability of the nations involved to continue the struggle. They will endeavor with all the influence at their commands to prove to the peoples opposing their nation that further continuance of the struggle is hopeless, that the cost will be too great, in other words break down the will to fight. If unable to accomplish this purpose and force an early peace, they then will be engaged in destroying those establishments of the enemy most vital to him in the carrying on of a prolonged war. Independent air force tactical operations may be divided into four principal groups: propaganda missions, reconnaissance missions, antiair force operations and bombing missions against vital targets.



The typical American aircraft factory from the air, like the Douglas plant above, is easily spotted by enemy aircraft. Compare this clear view with the Army's new camouflage system on the page opposite.

PROPAGANDA MISSIONS

It was a considerable surprise, and led to the application of the term "phony war," when the belligerents in the second World War did not instantly engage in a series of strong air operations against each other. There was witnessed a new use for the air forces—the leaflet war. Flying generally at night and at high altitude, formations of enemy bombers appeared over the centers of population of Germany, England and France and distributed leaflets pointing to the futility of opposition.

It is too early to take into full account the effect of the air propaganda mission. Some situations can be visualized in a war of ours where it might prove effective, indeed. It does supply an excellent method of communication with the secret agents of a nation inhabiting the territory of the opponent. It may be effective also where there are a considerable number of sympathizers in the opponent nation, or where a considerable proportion of the people speak the language of the attacking nation or have the hereditary ties of a once kindred people.

At any rate, it was employed for almost a year in our most modern war and cannot be overlooked as a mission for the air force. Such missions give combat crews flying time, experience, a view of future battlegrounds and an experience on new airways.

RECONNAISSANCE

To wage successful air operations against an opposing nation, it is necessary to know the location of the important targets. For many months the public press contained statements that German bombers were sighted over England at various points, but dropped no bombs. Similar reports came out of Germany. These were reconnaissance missions. It is not unlikely that every plane carried a powerful camera and that complete maps were made of the war theater on both sides, months before battle was actually joined.

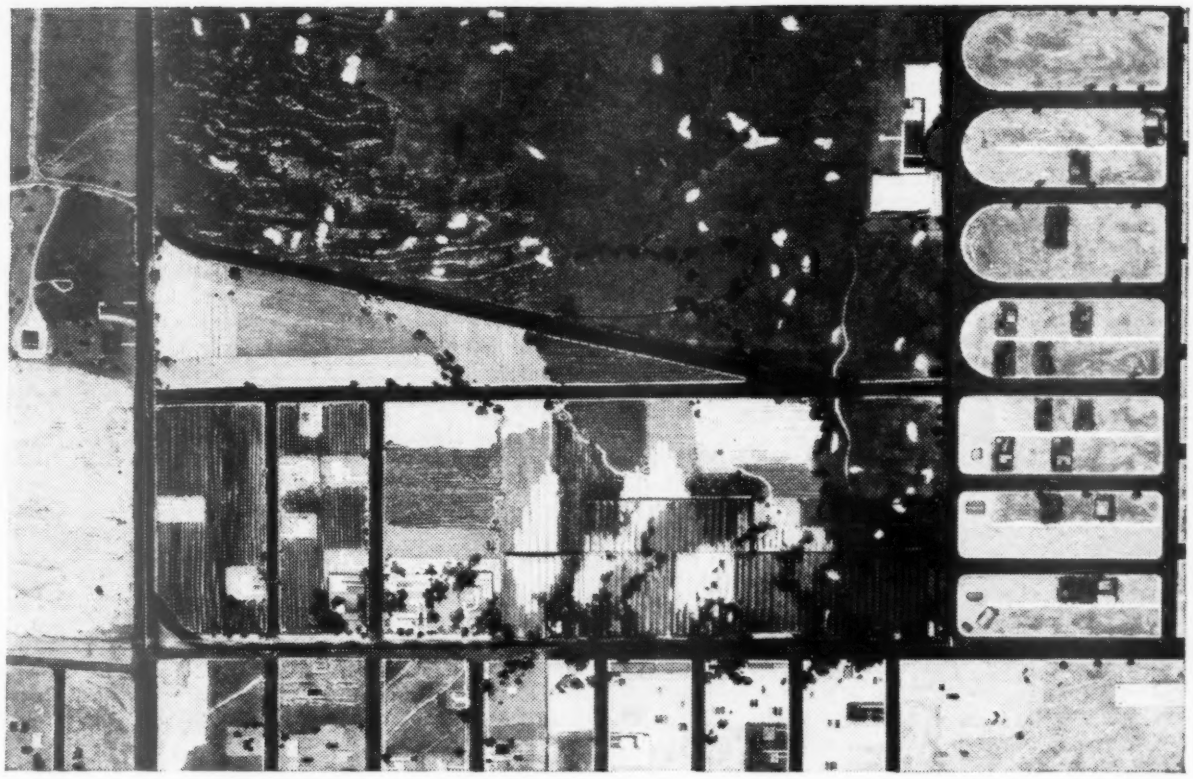
Bombardment units make up what they call objective folders. These are envelopes that contain all possible information about enemy targets. The reconnaissance mission provides most of the information for these objective folders. This information tells the airman what to destroy, what will destroy it and what will be the result of its destruction. It also tells him how to find it—day or night or in any kind of weather.

Other reconnaissance flights observe the movement of ships, rail and truck transport and troops. Some will be set to watch the habits and customs of the people. The airman flying at great altitudes can pick up valuable intelligence sometimes from the most inconsequential details. They will observe whether factories black out at night, whether business is being carried on as usual; whether populations still gather at race courses, athletic fields; whether the schools are still filled with children or whether the children have been evacuated to the country. In these and in a hundred other ways, the reconnaissance mission conveys intelligence as to the morale, preparations of the enemy for war and the location of his vital objectives.

The number of planes appearing daily on landing fields near an aircraft factory will measure its output. The number of freight cars leading from a munitions establishment will show not only how much it is producing, but where it is going, where it is being stored, where it can be destroyed.

The most vital of the reconnaissance missions, of course, are those which disclose information immediately before the air battle is joined. In our own country the most important reconnaissance missions will be those that locate the ships that bear the expeditionary force to our shores and which remain in contact with that expeditionary force until our own bombers arrive. Other valuable reconnaissance missions will be those which disclose the location of the enemy airdromes, how many planes and what type habitually occupy them.

Tactically, the reconnaissance mission is accomplished by the dispatch of fast airplanes flying at high altitudes, armed with special camera equipment. Many valuable reconnaissance missions are accomplished at night and in future wars a great part of the reconnaissance work may be done during hours of dark-



This photograph shows how the aircraft plant on the opposite page was camouflaged to prevent detection by enemy aerial cameras. With runways disguised and field blotted out, factory is well hidden.

ness. This is made possible by recent development in night photography. The value of the reconnaissance mission is in ratio to the training and experience of its crew. A reconnaissance plane avoids combat and relies upon speed and upon incidents of weather or darkness for its safety.

ANTIAIR FORCE OPERATIONS

Our military school books talk about destroying the enemy air force on its own airdromes—"Shooting the eagle on its nest." It worked in Poland, it worked to a considerable extent in France. There is, however, positive evidence it has not worked so well in England. Why? How were the British able to do what Poland and France could not do? As much as we can say now, it was careful planning and preparation.

If the enemy does not conveniently leave his airplanes on his normal airdromes; if he is so unco-operative as to disperse them widely or move them to other airdromes, or if he puts them underground, antiair force operation against airdromes will not be so effective. Hangars and permanent airdromes will be destroyed but the vital part, the airplane, will be left for revenge.

It will then become necessary to destroy the enemy air force in flight. This can be done in two ways. First, by sending over bomber formations and then, when the enemy fighter aviation comes up to join battle, accompanying fighters can destroy the enemy fighters. The Germans employed this method extensively in the early days of the Battle of Britain.

Another and less effective method is to meet the enemy bomber when he flies over your own terrain with well-equipped and superior fighter aviation and shoot him down before he has reached his objective. Both sides in the present conflict have striven mightily to accomplish this purpose. So successful have they been that bombings are now largely reserved for the hours of darkness and for bad weather.

Another system lies in the destruction of enemy aircraft factories. It is not alone the air force in being, but the air force which can be kept in being as the war continues, which will determine the outcome. Enemy aircraft factories, therefore, have high priority as bombing objectives. If these are not placed underground and are not dispersed widely and are not given the protection of camouflage and concealment, they are relatively simple targets. They can be destroyed by high explosives or burned by thermite bombs. The extent of damage will depend upon the efficiency of the attacker and the excellence of his equipment and upon the industry of the attacked and his intelligence in concealing or protecting his factory.

DESTRUCTION OF ENEMY MANUFACTURING ESTABLISHMENTS AND COMMUNICATIONS SYSTEMS

A large air force will not require all of its bombers for operations against the air force of the enemy. Persistent attacks will be launched immediately on those manufacturing establishments, power plants and lines of communication which are vital to an enemy in its attempt to gird itself for war. The degree of success with which the opponent can prevent normal efficiency in munitions establishments will have a tremendous bearing on the outcome of the long struggle.

It is generally accepted that bombing attacks on civil populace are uneconomical and unwise. Many reports in the present war in Europe of attacks on civil populations either are propaganda or due to mistaken identity, or inaccuracy on the part of the bombardier in the plane. Dense populations which reside in the vicinity of industrial areas, airdromes, navy yards and docks undoubtedly will feel the effects of poor bombing on those docks. If either of the combatants has engaged in attacks on people, such missions cannot be classified other than as decided tactical errors. The most economical way of reducing a large city to the point of surrender, of breaking its will to resistance, is not to drop bombs in its streets, but to destroy the power plants which supply light, the water supply, the sewer lines. Bombers in far larger numbers than are available today will be required for wiping out people in sufficient numbers to break the will of a whole nation.

It might be well here to outline a typical air force bombing

mission and the routine method of its accomplishment. GHQ calls the bomber command and says that an airplane factory thought to have been destroyed months before now is showing signs of operation, raw materials are flowing in, some new planes are appearing on an airdrome close by. It must be destroyed.

A trained bomber flight of six planes is assigned the mission. The target is 400 miles away; take-off is set for 12 midnight; the route is determined, the approach figured to avoid heaviest known concentrations of antiaircraft fire. Combat crews retire for rest, the maintenance crews continue to tune up motors, check all equipment.

Midnight comes; weather at home airdrome is soupy; individual take-off is announced, with assembly above the overcast at a predesignated altitude and over a well-known geographical landmark when visible. The flight leader moves out from the flying line to the runway, pulls his heavily laden plane from the landing strip. At one minute intervals the others follow. The flight leader pulls up through the overcast at 10,000, moves by celestial navigation to prearranged rendezvous point. At 1 a.m. the flight is assembled in formation echeloned to the right and heads on its course. All lights are turned out except a dim running light in rear and on top of each fuselage. Succeeding planes in the stepped-up formation follow tiny star-like specks on the backs of the preceding gray ghosts.

An hour later there is a brief flash of leader's wing-tip lights. All pilots see the warning and watch for the order to attack. It is clearing now; clouds are broken. Motors are throttled; there is a slow descent to optimum bombing altitude. The planes drop back and take up one mile intervals. Gunners are vigilant at gun stations; bombers uncover sights and clear for action. Soon a bright light bursts thousands of feet below; the leader has dropped a bombing flare; there below, light as day, stand out the forms of buildings. Immediately rocket-like bursts fill the elements, planes are rocked by rough air. The enemy antiaircraft has gone into action.

Then, there is a red-specked white burst far below in that hapless factory yard; number two was a little short; number three readjusts; other bursts cover the plane plant as each succeeding plane drops its deadly cargo. The leader has moved to a predesignated assembly point at full speed, others follow, moving through the great cloud patches for cover. The last plane lags a little, as he must photograph the job, take a picture of the work of the four which bombed the target. Searchlights stab the night, looking frantically for the six ghostly visitors. Off to the left, telltale streaks of moving light indicate that hostile fighters with engines full out have left the ground hurriedly and pulled skyward in steep climbs to hunt the slower enemy bombers, guided by searchlight beam and antiaircraft burst.

A hundred miles back toward home and the friendly solid overcast lies below. The bombers fall into it like children into a feather bed. No longer can the enemy pursuit trail the retreating explosive freighters. At 3:30 a.m. the leader, breaking through at 500 feet, comes in on a long glide and taxies to its area on a corner of the field. Others follow, park in their revetted nests in scattered areas. Tired crews gather at squadron operations for the discussion of the mission, to complete reports. A telephone goes to GHQ, "Mission completed, successful, photos coming over."

Not always is there friendly cloud cover; sometimes the searchlights catch a luckless bomber, enemy pursuit dives into blindest defensive spot. Gas tanks burst with puffs of flame, crews bail out. On more than one occasion upon returning after long hours away from the home airdrome the fog has moved in. Then the slower process of riding in on beams for blind landing is required. The crippled and limping planes, with an engine out, land on any airdrome they can reach.

On the long, climbing flights to targets, crews are not idle. De-icers must be set pumping when frost first shows on wing or cabin canopy; oxygen must be fed to crews; engine carburetors must be kept free of ice; navigators must reckon rightly and follow courses precisely; time schedules must be met to the split second: machine guns and sights must be kept warm. Here is teamwork of high order. On these simple missions only trained crews catch the signals and each player must do his appointed task as he has been taught and trained.

Some principles of air tactics already are fairly well standardized for all air armies. The offensive, fighting spirit must be instilled in all combat crews—particularly the pilots. The airplane is not a defensive weapon; crews must be bold and alert. Full advantage must be taken at all times of the element of surprise; surprise in time, direction, method and fury of attack. The fighter uses the cover of sun and cloud and falls on his prey in his blind spot. Speed, not maneuverability, is the prime method of escape from bad situations. Shooting is more important than flying; volume of fire at close range is what counts; long-range, hit-or-miss shooting wastes precious ammunition. Successful bombing is done largely at night; targets selected for night bombing must be illuminated. The size of the formation and the size of the bomb carried and its fusing must match the target to be attacked. Navigation is important; the target must be found before it can be destroyed.

The picture of the attack must be brought back; it shows crews their deficiencies; it may save the waste of further attacks. The greatest protection of the bomber, once it is discovered by enemy pursuit, lies in tight formation with the resultant grouping of defensive fire power; discipline in station keeping means safety; to scatter or break formation is disastrous.

The bomber must not turn and fight; his is not a fighting mission. His only objective is the destruction of assigned targets. He plows straight to the target, disdainful of bursting shells from below or lightning fighter thrusts from above.

Meticulous training and long practice are essential; the crew will never do better work when rocking in the tempest of antiaircraft fire or when enemy fighter bullets are tearing great chunks from their planes' metal sides. Untrained combat crews should never be entrusted to take bombers costing a quarter of a million dollars into tight situations.

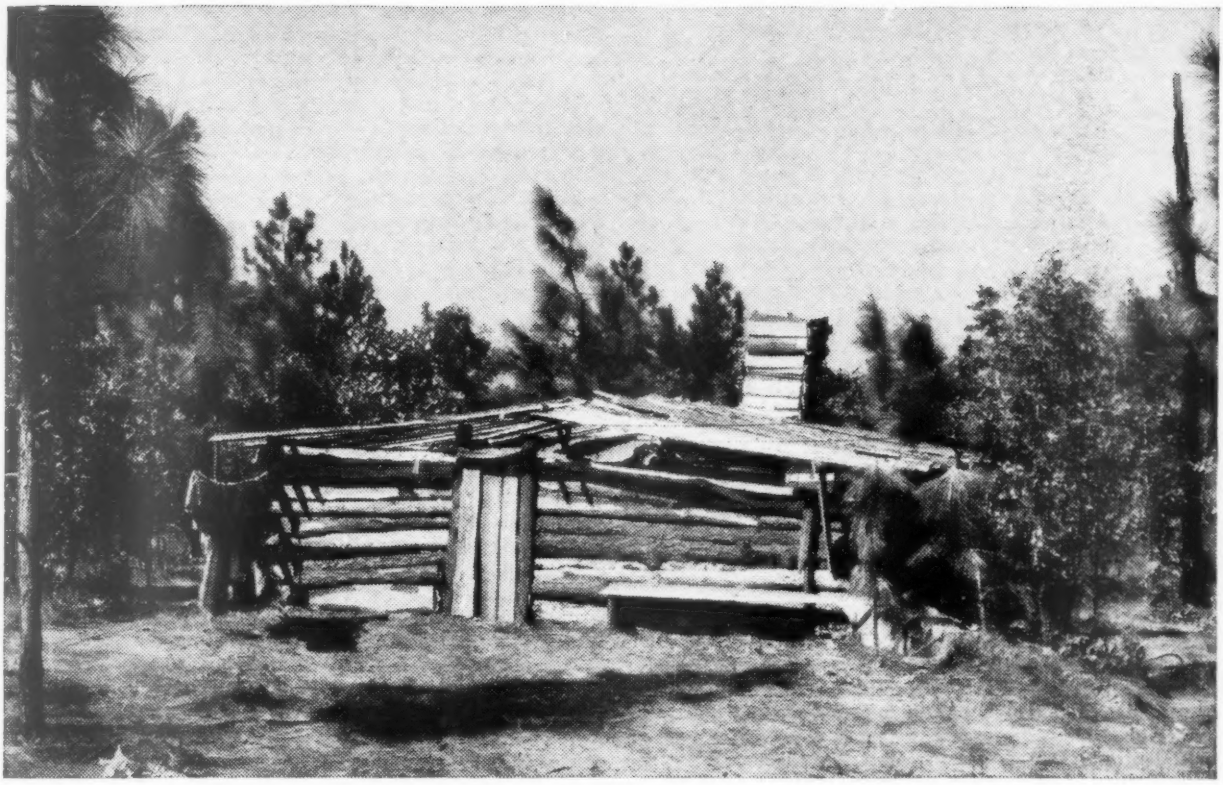
Try new methods when an old method of attack proves costly; shift promptly to new experiments. Air tactics must be elastic, changeable to meet changing conditions; airmen must be alert and open-minded. They must learn tomorrow's principles of attack from today's air battles.

Stouthearted leadership is imperative; vacillation, indecision, delay mean disaster; split-second thinking is the rule. Bold, aggressive leaders win air battles.

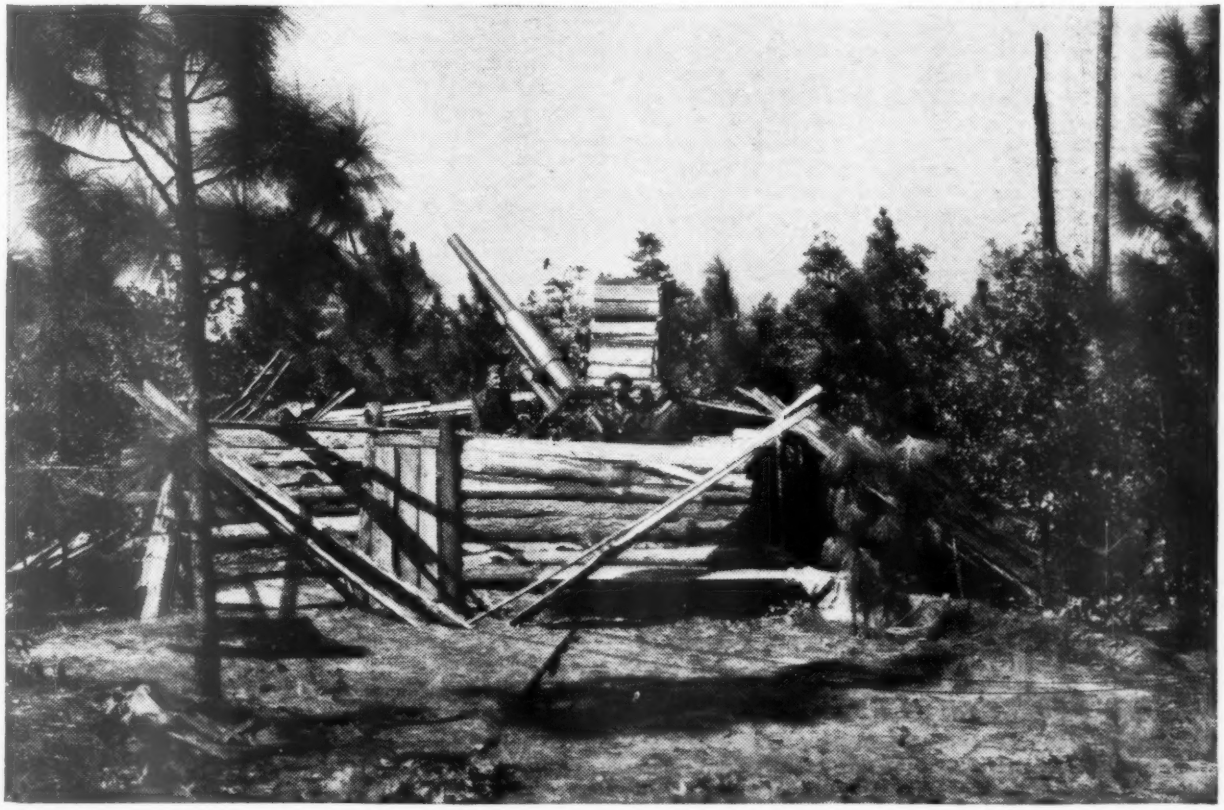
Airplanes must be kept modern, up-to-date in speed, protective fire power and weapons. Good crews must not be exposed in inferior equipment. After a plane type has been demonstrated as unequal to latest enemy development in air fighting, it must be withdrawn, sent back to the training fields. It is uneconomical to keep tactical units equipped with inferior planes.

Morale is more important for the air fighter than for any other military man. He must be instilled with the offensive spirit; he must believe in the justice of his cause; he must be clothed and armed and fed and rested on a par with his opponent. Most important of all, all members of combat crews must have the will to fight. Airplane crews can be overworked easily; a worn-out crew will have little efficiency. In air fighting, crews and planes must be conserved and not frittered away on useless targets.

New, metal fighting planes are stouter than the flesh and blood of their crews. They can be made ready for a return engagement before their crews can be rested. Multiple combat crews are necessary if the maximum efficiency is to be obtained from the modern aircraft.



Camouflage experts must be at their best when trying to hide antiaircraft batteries. One ruse is the rustic cabin, complete even to clothes on a line. The innocent-looking cabin above suddenly becomes a battery when the roof is dropped, revealing a 3-inch gun. Color photography will outsmart this.



Chapter Six

STRATEGY OF AIR FORCE OPERATIONS

"Air Power today has decided the fate of nations. Germany with her powerful air armada has vanquished one people after another. On the ground, large armies had been mobilized to resist her but each time it was that additional power in the air that decided the fate of each individual nation."

—Henry L. Stimson

STRATEGY is the art of war; it concerns those principles which a nation employs to overcome an adversary not yet on the battlefield. It involves the determination of when, where and with what to fight; the girding of a nation for war, the composition of its fighting forces. Their strength, equipment, armament, all these lie in the field of strategy.

Air strategy is the method by which a nation expresses its will through the employment of air forces. The principles of air strategy will dictate the creation of an air force, the type of its equipment, its composition, size, and the time and direction of its employment. In fact, everything which concerns the air force falls in the field of strategy until the air battle is joined. Then tactics take up.

There is a greater likelihood that poor strategy will cause the overthrow of nations than poor tactics. The determination of Germany, when she found herself blocked in the creation of a great navy, to employ an air force instead, was a strategic determination of tremendous influence on the present course of history. The failure of England and France to prevent that German air force, or to build more powerful air forces of their own, were examples of defective strategy.

The failure of all the combatant nations now engaged in the war in Europe to supply a proper proportion of long-range bombardment aircraft capable of reaching any target in possible hostile countries was a basic error in national air strategy. The present frantic efforts of all these nations to supply great flying fortresses with the range and speed and power to apply the checks of air power to any portion of the adversary country is a recognition of that error in air strategy.

CORRECT THINKING

Correct thinking is the basis of all successful strategy. There are many avenues for the expenditure of profitable thought by the national fathers as they play the role of air strategists. They must ponder over our possible enemies and our likely allies. They must determine the size and character of our Air Forces. They must prescribe its training and provide its equipment. They must determine to what extent they will organize and direct the industry and economic structure of the country to provide and support adequate air defenses.

OUR POSSIBLE ENEMIES

In conjuring our possible enemies our endeavor goes immediately into the field of diplomacy. The statesmen make and light the fire under the war witches' cauldron. The military men have but to stir and serve this brew.

There was a time in history when enemies and allies were traditional. One has but to look at the changing map of Europe, at the strange new bedfellows in the present conflict, to realize that that time has passed. In the 25 years since the line up for the first World War, adversary has become ally.

The present realization that allies, as opponents, are not fixed and definite and lasting, has a tremendous effect upon armaments, their size and structure. It appears that the only safe thing to do today is to prepare to meet the best combination which conceivably can be brought against us. That admission adds tremendously to the size of our military establishments. It adds greatly to the cost of armaments. But a second-rate air force, as Poland found, is worthless. In building our air forces we should make them competent for independent operation without any supporting allies whatever.

An air force, unlike a navy, has the mobility which permits it to fight on either boundary or in either theater simultaneously or within a few hours from the time of its presence on a distant coast or a widely separated theater. It makes it unnecessary to build a two-ocean air force. It is unnecessary to arrive at a determination as to whether our most likely enemy lies across the Pacific or across the Atlantic, or whether he will attack from east, west, north, or south.

SIZE AND CHARACTER OF THE FIGHTING MACHINE

Wise national leaders ask themselves the question, "What are our requirements by way of air forces? How big must they be to give us adequate protection? What types of aircraft must we build, and in what proportion?"

Sound thinking should indicate these answers. An air force must be large enough to prevent the incursion of any foreign establishment. It must be able to concentrate more aircraft in any of our critical vital areas than can be concentrated for attack against these establishments. We know today what combination of air forces may conceivably attack us and we know their composition, their power, range and speed. We know the two methods that could be employed in reaching us, the one by direct flight by way of Newfoundland or South America and the other by transport on water-borne bases.

It is not only important to measure accurately the strength of the opponent today, but to look into his war chest to see what he will have in the near future, to study his plans and his intentions, his industrial establishments, his power for making war weapons. His state of mind, his national will, must be gauged, as well as the purposes which they indicate.

There are several limitations to the size of an air force. Fortunately most of these do not seriously limit us. The size of the aircraft industry, the quantity of raw materials, the proportion and numbers of the population suitable for air combat, all are limitations which greatly restrict or delimit the size of the air forces in most nations of the world. In our own case it lies within our power to build the greatest air force in the world.

There is always discussion of the relative merits of a defensive as against an offensive air force. It is possible to build an air force purely defensive in character, consisting entirely of fighter aviation, on the theory that if a nation has enough fighter aircraft it can prevent the incursion of bombardment aviation. Wise air leaders now know that this is an untenable theory. Bombers are winged, long-range artillery. They can no more be stopped completely once they have taken the air than the big shell can be stopped once it has left the muzzle. Some of them may, and probably will, always be shot down. Some of them under favorable conditions will be destroyed. Some will get through. Under certain conditions of weather and at night many will reach their targets. Air forces are strictly offensive in character. They are not Chinese Walls or Maginot Lines which can be stretched along the boundary and relied upon to turn back the invader. Their defensive powers lie in their ability to go out to meet the aggressor. They work also against the nest of the invader, the foreign air bases, and against the father and mother of air forces, the aircraft factory and industrial establishments.

TRAINING

Strategy considers the field of training. On more than one occasion it has been demonstrated that a small, superbly equipped and thoroughly trained air force can overcome without difficulty one superior in size but deficient in training, arms and equipment. Great pools of available possible pilots and mechanics are as far removed from effective airmen as mahogany trees from fine furniture. Combat crews must be highly trained; air leadership must be schooled in the ways of air fighting and perfected in technique and full-scale maneuvers. Air strategy teaches that the air weapon is an intricate mechanism, expensive and dangerous in the hands of the amateur and capable of effective use as a fighting weapon only when built and maintained and directed by skilled, schooled personnel.

THE TIME PHASE IN AIR STRATEGY

Chronologically there are three phases in air strategy, the strategy of preparation, the strategy in fighting and strategy in peace negotiation.

The time for mobilization has undergone great change of late years. The personnel to be mobilized have also changed. In the time of our Spanish American War, mobilization was concurrent with the declaration of war. As late as the first World War there was little mobilization prior to the actual time of the engagement of armed forces. There was a time when only military men were mobilized. That is now not enough. Some of our military leaders now realize that the mobilization of uniformed man power is even less essential than the mobilization of industrial man power. They must be carried out hand in hand.

This time phase in mobilization is many sided. A determination must be made as to when industry will be mobilized. The yardstick for that determination is this: it must be mobilized in ample time to build the machines of war and have them ready at hand completed in adequate numbers when war is declared or invasion comes.

We must, therefore, change our own concept on mobilization. It is not concurrent with declaration of war. It is not initial in the beginning of hostilities. It is a preliminary prerequisite. Correct thinking and sound air strategy will indicate when this mobilization must occur. If unsound conclusions are arrived at on this score, as France found out, the war will be lost.

There is another time factor in the provision of air defenses which must not be overlooked; that is the fact that air forces, like naval forces, must be at operating strength before the war starts if they are to be instrumental in turning the tide of that war.

Maj. Gen. Frank M. Andrews, first and for four years Commanding General of the GHQ Air Force, reiterated this truth in these words.

> It must be realized that it takes time to build a force of modern military aircraft, and further time to train the men to fly those airplanes and maintain them on the ground.
>
> The existence of potential air power is important if it is utilized to create actual air power before the necessity arises to use it. The most fertile agricultural region would be of no value to save a people from starvation if it were not sown with crops and those crops harvested before the specter of famine presented itself.
>
> So it is with potential air power. Unless developed before the emergency occurs, it will be of little value afterwards, not only because of the time factor involved, but also because aircraft factories and engine factories are early objectives of a hostile air force.
>
> I repeat, adequate air power cannot be created after the necessity for it has arisen. Like a navy, it takes years to build an air force.

THE STRATEGY IN WARFARE

After the first shot is fired, after the first drums beat, when mobilization is complete, when the armed force is drafted to full strength, there are then strategic considerations concerning the waging of actual conflict.

When shall the air force enter the struggle? It should be the first force used. It is the shield which will ward off the first air blow of the enemy. And the first bolt the enemy hurls will come through the air. The effect of that destructive force can be minimized by proper strategic employment of our own air force. If its use is to be correct and timely, if it has the superiority which sound strategic thinking in the first phase would make likely, it will neutralize the air blow of the enemy, just as German employment of her air force on Sept. 1, 1939, rendered the Polish air force powerless to strike back.

There is a defensive phase in air strategy, also. Most defensive concepts against the enemy air weapon lie in the field of strategy. These are examples: the maintenance of high morale of the home populace; the provision of adequate air-raid shelters; the placing of our vital establishments underground or of covering or camouflaging them so that they will not be seen and destroyed by the enemy; the provision of adequate warning nets; distribution of fighting aircraft in proper numbers in proper places; providing antiaircraft and balloon barrages. All these, like mobilization and like the building of an air force, are strategic concepts. The nation which provides clear, concise answers will come out on the winning side.

STRATEGY AFTER WAR IS OVER

Generally, when wars are over, as in our own Armistice of 1918, there is a great immediate exultation. There are celebrations of victory. Armies are disbanded, air forces are thrown in the junk heap, and navies are tied up to piers to rust away. Despite the fact that wars, even for our own peace-loving people, have occurred in every space of 40 years we always celebrate the conclusion of one struggle by making it almost impossible to fight the next one.

There is another phase, too. During the long years of the struggle, we watched the enemy's every movement. We have parried every blow, but at last, having conquered him, we relax. He then can rebuild his battered war machine without our knowledge or notice. A victorious England and France permitted Germany to prepare the largest military establishment and the most effective air force in existence without raising a hand. England's capital and English support aided in the building of that tremendous war machine. Germany began to build up in 1933 in dead earnest. At any time prior to 1937 France and England could have called a halt. Yet no serious protest was made.

Sound thinking, correct strategy, indicates that it is unwise to dismantle or destroy all military establishments immediately upon the declaration of a given peace. It is now pretty generally conceded that a tremendous armament is the only assurance for peace in a world peopled by the inhabitants and controlled by the governments now existent. That being the case, it is unwise indeed, at a time of temporary lull, to throw away establishments and machines and armaments which have taken billions of dollars to build and millions of hours to fabricate. A wise nation will disarm slowly. It will continue, long after the blood has dried on the battlefields, to train skilled workmen in the factories, to train young flyers and drill young soldiers, and maintain a military might that will maintain it still as an uninviting target for ambitious attack. Likewise, national statesmen will continue to watch the beaten enemy and enforce vigorously provisions in the peace treaties against rearming. The snake under the heel must be kept under heel, lest he come to life again at sunrise.

OUR PRIMARY STRATEGIC PROBLEMS

In the realm of air strategy our primary problems are these: the determination of the air requirements in hemisphere defense; the development of a balanced air force sufficient in size and power for the destruction of any opponent or invader who attempts to reach our shores by air, land, or sea; the provision of an adequate industry, capital, structure and trained man power to maintain this air establishment in fighting trim.

AIR POWER FOR HEMISPHERE DEFENSE

Just as the Monroe Doctrine always has indicated the measurement of our Armies and Navies, now the annunciation of the principles of hemisphere defense cuts the cloth for our Air Forces—indicates its size and composition.

Every citizen of the United States who is interested in his own Air Forces should study a globe of the world. He should note the extent and position of the Western Hemisphere. He should ponder well the stepping stones from the old world to the new. Modern bombers can reach our critical industrial, mobilization or strategic areas by using them.

Thus far, air aid from our neighbors presents a gloomy prospect. It is indicated pretty clearly that now and for some time the air forces which protect the Western world will have "U.S." painted under their metal wings. After the citizen has become familiar with this hemisphere he has vowed to defend, let him then ponder who is likely to attack it. When he has located those nations, eastward across the Atlantic or westward across the Pacific, let him consider how far our own bombers must fly in order to destroy the enemy air force on his bases and to demolish his factories to prevent him from making weapons he can float or fly to our shore.

This will indicate an important strategic concept for the building of our own Air Forces. It will indicate that giant planes of vast range are required to do the work.

It has not been entirely due to faulty reasoning that 10,000-mile bombers have not been produced in quantity. The art of the aircraft industry and the size of the airplane power plant had not developed to a point where planes of this size were possible until relatively recent times. It is now evident, however, that no longer is this an adequate excuse. Germany found that the nation which builds the greatest air force first probably will be able to conquer Europe. It may be that the next national determination will be that the nation which produces 1,000 10,000-mile bombers first will be able to conquer or save the world.

Certainly the requirements of hemisphere defense, if thoroughly comprehended, indicate the kind of an air force which the United States must provide in order to enforce it. Not long since an American airman showed how Germany might determine how serious we are about hemisphere defense at little cost and effort.

"If Germany flew 1,000 bombers to Brazil," said he, "and landed them on airdromes prepared by the millions of Germans now resident there, supplying through the air the necessary bombs and fuel, it would be necessary for the nation which would enforce Western Hemisphere defense to drive those bombers out. But no land or water-borne army can approach Brazil under the sphere of influence of those 1,000 bombers until the bombers have first been destroyed or driven out. That means, then, that the nation which would dislodge those German bombers must have an air force with sufficient range to destroy those bombers on their Brazilian bases.

"If such an air force were available and were directed energetically at those Brazilian based Europeans, they might be flown home to Germany, or be reinforced. The ensuing air engagement would largely determine the issue. Certainly it would settle the first or the air phase. This," he pointed out, "is how easily an aggressive foreign power could test our doctrine of hemisphere defense."

THE BALANCED AIR FORCE

Much has been intimated under hemisphere defense about the necessity for the long-range bomber. The provision of adequate air bases well distributed throughout this Western Hemisphere, reduces in a measure the necessity for long range. It indicates that a plane of 10,000 to 12,000 mile range, although desirable for direct action against any possible opponent, might be substituted for by a plane of 3,500 mile range, if adequate bases in all theaters are provided. Bear in mind also that the 5,000 mile bomber is still on the drawing board and even if purchased now, could not possibly be flown for another two years. That indicates how far in advance our plans must be completed.

Correct air strategy indicates the training of pilots and mechanics on a large scale to maintain the airplanes of the number required to insure the protection of the Western world against any coalition of adversaries.

In considering air strategy it is neither necessary nor wise to assume that the whole defense of the Western world is an air problem. That is not intended. It is now definite, however, that neither land nor sea forces can fight land and sea battles to successful conclusion unless the air above them is kept free of opposing air forces. The problem of hemisphere defense is a tripartite problem. It involves air forces, sea forces and land armies in correct proportion, under a common command and with a common objective. These forces must be trained to work together. Their orders, signals, codes, systems of communication, must be common in character and subordinate leaders of each of these three subdivisions must thoroughly understand the tactical employment of the others. Without these essentials there cannot be that true co-operation in the task force which is essential for success in modern warfare.

THE INDUSTRIAL PHASE

Civil industry created the original air force. Civil industry must maintain it. This business of healing the wounds and providing replacements to a fighting air force is no insignificant task. Some profess to believe, and the encounters in the European war lend some color to this belief, that engaged air forces will lose as much as 50 per cent per month. That means that if we entered a war with 10,000 fighting planes and all those planes were engaged, 5,000 planes a month for every month the whole force was fighting would be the required capacity of our aircraft industry, merely to maintain those 10,000 planes in battle.

That is a staggering conception. Fortunately, it is not quite that bad. There is no sound military leader, who, possessed of an air force of 10,000 planes, would engage all of them at one time or continuously. No military leader has sent armies or navies all out to continuous battle. There may be considerable periods of time, however, such as have prevailed in England during the months of September and October, 1940, when a whole air force will be engaged for a considerable period of time.

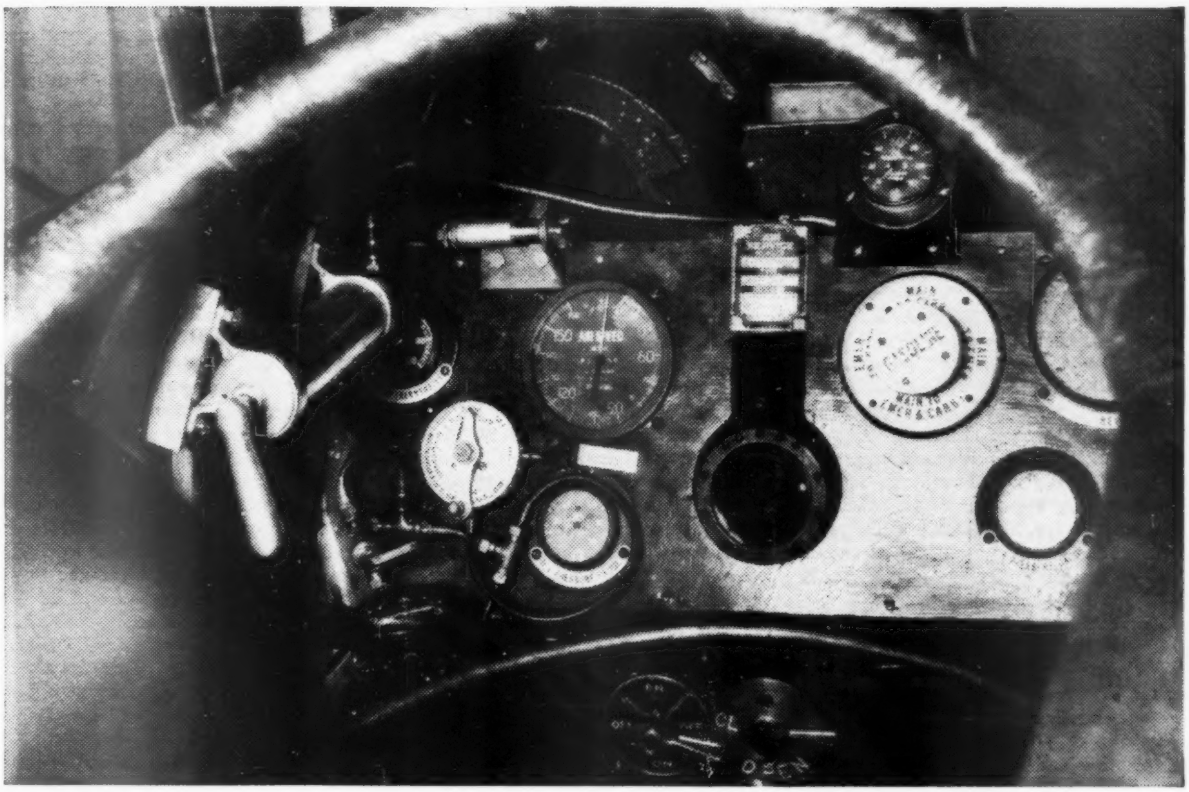
It is reasonably safe to say that a nation with an air force of 10,000 fighting planes, if attacked by a larger air force might well require a replacement of at least 30,000 planes per year. That means a tremendous aircraft industry. That industry must be operated continuously, three shifts per day, and its efficiency must be maintained under the conditions which are likely to pertain in wartime. The life of a nation may depend not on the success of the air fighting, but on the ability of the industry to maintain the fighting forces at full strength in arms and equipment. That industry is made up of three essential elements—capital, labor and production facilities. Factories in sufficient numbers must be provided either by private industry or the government. There must be a quantity of skilled labor to fabricate 30,000 planes per year, and capital and leadership must be provided to pay the bills and control the establishments. These three must work together in harmony in a common accord. Since it is vital to the government that they do, it is a function of the Government to insure that they do.

No more important strategical problem faces a beleaguered nation. Failure to provide for union of these three elements caused the fall of France and placed England's back to the wall in a life-and-death struggle. The ability of the attacker, Germany, to co-ordinate these three essentials in proper proportions and to a common purpose, permitted her to build an air force for world domination. This is not a plea for a totalitarian government. Wise, farsighted leadership in a democracy can enforce the co-operation of these three elements to a common end. Only in this way will a large air force be maintained in continuous operation.

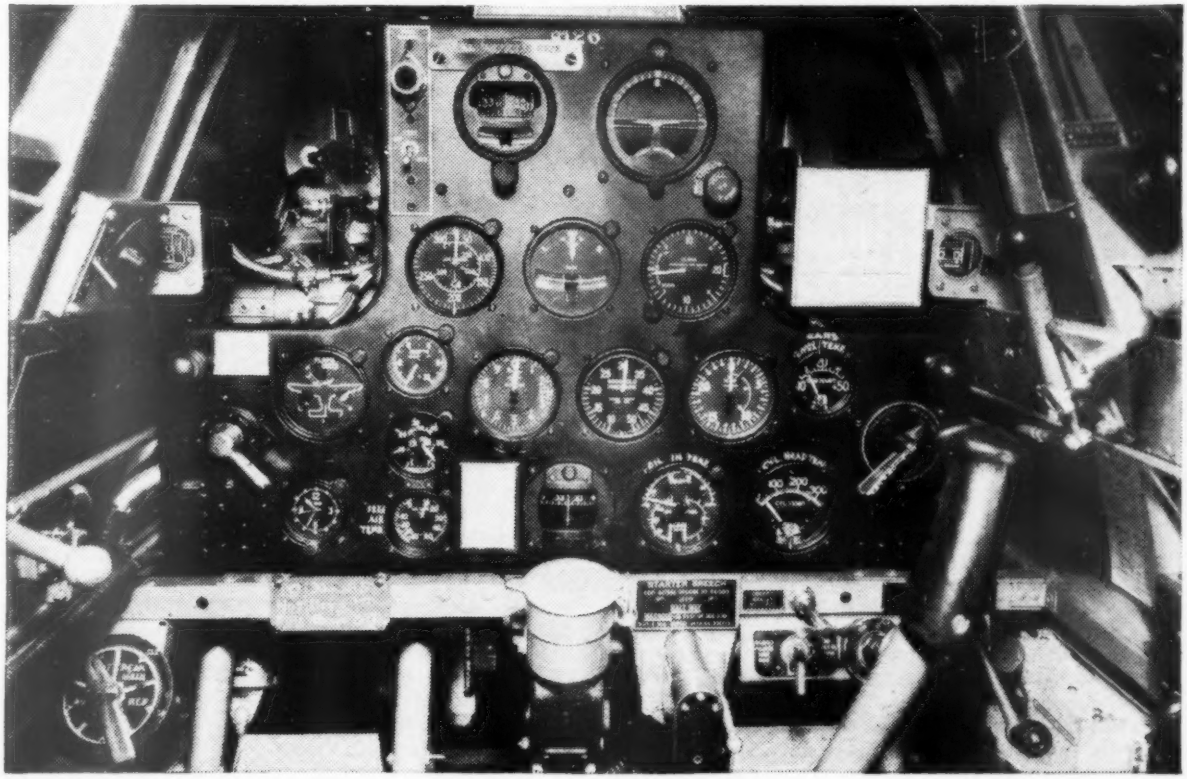
LEADERSHIP AND STRATEGY

It is unavailing if a few men perceive the correct principles of strategy and go about a nation thundering them in vain. There has been no dearth in this country of a few outstanding leaders, who have realized correctly the principles of air strategy and who have propounded them to all who would listen and many who would not. Thirty years ago, Gen. James Allen, the Chief Signal Officer of the Army, issued this warning to the American people: "Military aviation is a subject which we must seriously consider whether we wish to or not, and the sooner this fact is accepted, the better it will be for national defense." That statement was made by him to the Congress in a vain appeal for funds. The Congress of that year did not appropriate money for a single plane.

On the other hand, let us see what happened to a national strategist in another land. General Ludendorff, famous World War commander, retired from active service following the close of the first World War. He began to study the reasons for Germany's failure. Strategy was his passionate pastime. Finally he put his ideas on paper in the form of a book known as a *Der Totale Krieg*. There in that little volume which the German people took to heart, but which received too little



Instrument panels in pursuit planes have accumulated more dials and controls than the pilot can read in a single glance. The authors describe the strain of concentrating on these instruments in the midst of battle. World War pilots had very little to watch in their SE-5 cockpits except altimeter, oil and fuel dials and switches (above). Large cylinder and handle at left is gun synchronizing gear. Curtiss P-36A (below) has about 50 dials and controls.



notice in the rest of the world, the brilliant old strategist outlined all the principles of the Blitzkrieg.

As *Mein Kampf* was a widely publicized book of Hitler's declarations which were to be followed by him closely, so *Total War* by General Ludendorff outlined the strategic conceptions upon which the German army and air force were built and which governed their employment to the present time.

It is not enough for sound principles of tactics and strategy to be thoroughly instilled and inculcated into the military establishment. They must be known and followed by the political leaders. They must become the directing force, the motive energy behind the concerted effort of a united people.

STRATEGY IN PROPAGANDA

Propaganda always has been employed by successful military leaders. It is the name, not the effect, which is relatively new. It is true, however, that it never was employed so energetically nor upon such a giant scale as has occurred in recent wars. This is due in part to what modern invention has done for the rapid dissemination of intelligence. The Germans were the first to realize the full importance of this weapon and the first to undertake it on a vast scale. It is particularly insidious because no walls can be built to keep it out. The antitoxin must be applied individually. Each mind which hears and construes the words coming over the radio and sees the printed word on the air leaflet is a subject for the disease, hence the requirement for individual vaccination.

The Western Hemisphere is a fallow ground for propaganda because of the many nationalities, differences in language and the differing historic backgrounds in the nations now occupying the Western world.

Sound-thinking and well-planned strategy will not overlook the power of propaganda and will provide for an effective organization and machinery for its clever dissemination and for the rebuttal of foreign propaganda loosed on our peoples.

Chapter Seven

DEFENSE AGAINST AIR ATTACK

"What a depressing commentary on the follies of human nature that in the year of Grace 1939 civilization should be forced to defend itself with gas-masks and underground cellars, that human beings should be taught how to become once again cave-men, and to shelter themselves in darkness and in the bowels of the earth. The cynic seeing these things would abandon all hope.

"But detest as they might, the need for this expenditure and the causes that led to it, as practical men and women they must set their teeth and see to it that until the world regains its sanity, the priceless treasure of British civilization should not be endangered by ruthless and inhuman raids."

—Sir Samuel Hoare, Home Secretary for Britain

NAPOLEON is alleged to have said that a vigorous offense is the best defense. It will appear, before this chapter has run its course, that Napoleon's observations about defense in warfare are as true for an air warfare as for land battles.

The first World War closed before very serious consideration had been given to a checkmate for air attack. The years of peace that followed found experts in all military research laboratories working overtime to make the modern airplane a better, a more efficient, a much greater destructive weapon.

In the Ethiopian campaign there was little opportunity to employ modern methods against hostile aircraft, since the Ethiopians had no modern military planes. These semicivilized nomads did, however, learn to scatter at the sound of airplane motors and to take to cover in the luxuriant vegetation of their native land. They were wont, also, to concentrate rifle fire on low-flying attack aviation. Dispersion, concealment, camouflage and small arms fire were their only answers and these were employed in the crude ways to be expected of a people whose armaments had not kept pace with civilization. They were but half schooled in killing, half skilled in defense.

Ethiopia was not a fruitful target for air attack except against troop concentrations and primitive supply columns, since there were no manufacturing establishments, no real lines of communication, few ammunition and supply dumps and depots and no great centers of population and industry. Little can be learned, therefore, from the Ethiopian campaign, about air defense.

The Spanish Civil War, which has often been termed an air proving ground, was the next modern theater for study by the military student in defense phases of aviation. Both the Loyalists and the Nationalists felt sufficiently the sting from the skies to be moved to defensive measures. Both sides soon learned that transportation, rail and road, must move at night and without lights. Both learned that unprotected surface water craft must not be exposed to bombardment aviation too often or too long. Both found that an air force has a peculiar liking for docks, railway stations, railway bridges, troop concentrations, powder plants and supply depots.

Their answer was an industrious employment of the hours of darkness. They learned dispersion, both of airplanes on the ground and of soldiers on foot and in trucks. They practiced considerable of the art of camouflage. Dummy airplanes were reported on some airdromes. They used trees and natural cover and developed some artificial and painted cover to hide essential installations. They learned to move their airplanes from one airdrome to another frequently. They found it wise to employ temporary airdromes as against the permanent variety.

The Spanish Loyalists found to their surprise, and incidentally it was brought home with surprise and confusion to military men in other nations, that steel and reinforced concrete are not a complete barrier to the heavy bomb. This was discovered at Bilbao when the Germans freighted in heavy bombs and melted down a modern concrete "little Maginot" line around that city.

Here in Spain were the first crude air warnings, the first faint evidence about what could be expected later in some other and more important localities.

The Chinese discovered that heavily populated areas such as theirs are especially vulnerable and are inviting targets to the misguided airman who desires to attack civil populations. They found that wood, pasteboard and paper cities burn readily and are easily ignited by the thermite bomb. They confirmed many of the discoveries which had earlier been made in Spain about the enthusiasm of the air attacker for railroads, highways, supply ships and factories. Their weak little air force discovered that the first target for enemy air attack is the airdrome and the aircraft factory.

The stoicism of the Chinese people under Japanese air attack deserves the commendation of the world. Many of their responses were prompt and highly intelligent. After the first attack they moved their two aircraft factories far inland and dispersed the buildings of those factories so that one bomb would destroy but one building. When the drone of the bomber was heard overhead the airdrome detachments moved airplanes out of hangars and around the perimeter of the field, scattering them widely. Then, when the rain of bombs had ceased, they took up their crude tools, put thousands of coolies to work on a single field and had its landing surface smooth again by sunset, removing all telltale scars of a noon attack.

The Chinese discovered also that wartime industry survives best at night. They found it necessary to break up long truck columns, to run the railroad trains through at night without lights and not to mass troops in tight concentrations. The people learned after a couple of years not to huddle in masses like frightened quail when noises came from the skies, but to stay inside and off the streets when explosions were heard in the public square and down by the railway station.

From the limited air operations in Ethiopia, Spain and China, many keen observers in many foreign lands drew many lessons. There were some generalizations about air defense, but no very concrete, definite doctrine was developed.

Then, the air cavalcade moved to Eastern Europe. The Austrians saw how air troop transport and the co-operation of attacking aviation with motorized, mechanized forces can

conspire to bring lightning war. They sat in at the birth of the blitzkrieg. The collapse and surrender of the Austrian forces and the lack of opposition prevented reliable conclusions from that theater as to how best to combat the air invader. Poland was therefore the first real air battleground. The Poles discovered that a weak air force, like a weak navy, is scarcely an asset and may be a liability. They did find, however, that an air force, whatever its size, will be the first target an alert enemy air force will attack. They discovered that airplanes concentrated in the hangar or inert on the flying fields will be bombed or burned. The Polish government made an important, new discovery. They found that horses and men of an army harassed from the sky cannot walk to battle. What is more important, they cannot walk away from battle. Airplanes and tanks—tanks on the ground and airplanes overhead—can surround and cut to pieces men who must rely upon their own agility or the speed of horses to carry them to or from the conflict.

They rediscovered many of the lessons which might have been drawn from Spain and China. They found that rail lines and key bridges will early be destroyed. That transport, rail and road, must move at night. That supply and ammunition concentrations must be concealed or placed underground. They were the subject of another initial test. At one point in their battle when two land forces were tightly locked and it appeared that the Poles were gaining an advantage, Germany shifted her air force from its normal targets of matériel objectives and transportation and factories and moved it for six hours to direct attack against the Polish front-line troops. That swung the tide of battle. The great flexibility of the air weapon, its power against troops when unopposed in the air, was thus demonstrated conclusively.

The ill-fated Poles discovered also how a beleaguered city may be taken despite Chinese walls and stout defenses of earth, concrete, and bayonets. By the merciless aerial bombardment of a limited area, a city like Warsaw can be sacked and burned by winged artillery, they found.

Unreeled before their eyes was a perfect picture of close coordination and co-operation between mechanized forces and flying forces. The Poles found no adequate answer because they were unprepared initially and because they had failed properly to appreciate the full effect of the spear which was to be thrust through their flimsy shield. Some observers who watched their plight chanted some old lessons and suggested some new ones. They said air forces must be in being when war starts. It was quite clear that fighting aircraft cannot stop bombers unless the fighting aircraft is present in sufficient numbers and takes the air under skilled, valiant leadership with trained combat crews in the cockpits. Foreign observers were disappointed at the inability of antiaircraft fire and small arms fire to close the flaming mouth of the flying dragon. They engaged in some speculation and calculation as to what a tremendous number of antiaircraft guns and weapons would be required to stop a large and vigorous air assault.

Next comes Norway, then Holland, Belgium and France. In these theaters there was not a new show, merely the old act with a bigger cast. Everybody says now, "Why did not the Dutch, the Belgians, the French read promptly and correctly from the misfortunes of Spain, China and Poland, and prepare an adequate antidote?" There are plausible answers. In the first place, they did not read and interpret the lessons correctly. In the second place, they did not evaluate the industrial progress and air units and motorized ground forces created by their nearby neighbor with accuracy, nor attach to these things the importance they deserved. In the third place, time was not given them properly to revamp their structures, discard outmoded ideas, prepare new mail and shields.

So, we come to the Battle of Britain. Here for the first time, an invading air force has met a stouthearted air force, a sturdy foe and a stiff-spined opposition. Thus, from the beginning of the Battle of Britain in the late summer of 1940, a new chapter is being written, outlining the best antidote against air attack. From all of these modern engagements we here in America may draw some standard conclusions and prescribe some definite theories on air defense with practical illustrations on every other page.

COUNTER AIR FORCE MEASURES

Counter air force measures have been subdivided by the military school men into two principal categories and labeled direct and indirect. Direct measures are those in which positive forceful action is taken against the attacking vessel; indirect means are those by which an effort is made to circumvent or minimize the danger, such as by hiding it from the bomber or by scattering it so as to make an uneconomical target.

DIRECT COUNTER AIR FORCE OPERATIONS

In organized conflict, as in personal encounter, it is generally better to take positive action against the opponent, to injure or damage him in a direct way, than to attempt to hide or evade. There was much discussion until recent times about the best direct form of counter air force operations. This generally developed into heated arguments between airmen and antiaircraft artillery men. The recent wars in Europe, as well as the earlier struggles in Spain and China, demonstrated conclusively that although quite a few planes can be brought down by antiaircraft artillery, the only sure way to destroy an air force is with fighter aviation. A bigger and better air force is the only effective answer to opposing air power. There have been estimates from many sources as to the relative number of airplanes shot down in aerial combat as against all types of small arms and artillery fire from the ground. They range from about 85 per cent chargeable to fighter aircraft and 15 per cent to artillery, to a 70-30 ratio. It is now quite clear, however, that by long odds, the largest number of enemy aircraft have been destroyed by opposing fighter aviation. This does not mean that all other forms of counter air force operations should be discontinued or discarded. The best policy is to hurl everything, including the water bucket, at an invading air force—fighter aircraft, antiaircraft artillery, barrage balloons and bombardment of airdromes. Everything must be done which will disconcert the pilots and bombers and render their bombing less accurate.

So far as is known, the tactical doctrines of most of the air forces of the world held, until recent times, that an air force was most vulnerable on the ground and that it was of primary importance, therefore, to make the first objective destruction of enemy air bases. "Shoot them on the nest," was the cardinal slogan. The events in Europe in the late summer and fall of 1940 considerably changed that doctrine. It was found that the attack of airdromes is uneconomical and unsound if the opponent takes reasonable precaution to disperse planes between airdromes and to scatter them widely on individual fields. However, planes aligned with military precision or concentrated in groups or in hangars are still fine targets for any bombing outfit.

We are back then to the recognition that an air force in being must be destroyed in the air or while being constructed in factories. The light, fast, maneuverable fighter, single-motored or bimotored, carrying six, eight or 10 machine guns and a couple of 20 mm. or 37 mm. cannon, is the best antidote to bombardment attack. The Royal Air Force has demonstrated that a well-equipped and courageous fighter command can, until it is worn out or greatly reduced in strength and efficiency, make the attack of bombing formations expensive and uneconomical.

The pursuit plane or fighter has a distinct advantage over the bomber. It can select the time and place of attack and it can elect the direction of attack. Experienced fighter pilots always elect to attack the bomber from the angles where offensive bombardment cannot aim his guns or make hits—in the blind spots. It is remarkable how quickly fighter pilots determine from what angles they can fly in close to bombers with least likelihood of damage to themselves. Some types of bombers in both England and Germany have suffered such

Deadliest weapon against the low-altitude attack plane is the U. S. Army's .50 caliber machine gun, now replacing all .30's.

serious losses that they have been quickly withdrawn from daylight attacks and have either been discarded or reserved strictly for night operations.

During daylight in good weather, when pursuit aviation is present in strength in an area, it can pretty nearly bar the air to the bomber. Night fighters making attacks are greatly handicapped, however, in locating enemy bombers. The searchlights and listening devices of the antiaircraft aid materially in this regard, but do not provide an infallible means of obtaining a position from which the kill can be made. They also disclose the locations of the fighters and incur enemy retaliation with machine guns.

The outstanding example in all the annals of aerial warfare to date where the fighter swept the skies of hostile aircraft in a given area occurred above Dunkerque during the evacuation of the British Expeditionary Force. However, the fighting pursuit plane cannot take all the credit for this brilliant British withdrawal as the fog—a natural enemy to all aircraft—played a most important part. It may now be said that until new air battles disclose new methods and weapons that the fighter airplane is more than a match for the enemy bomber in daylight and is a very good counter measure even at night.

ANTIAIRCRAFT ARTILLERY

Antiaircraft artillery as a counter air force weapon is important and cannot be overlooked. Aside from its actual destruction of opposing bombers it has three outstanding advantages. It co-operates with friendly pursuit aviation by revealing the location of the enemy bomber formations. Many a fighter pilot has been steered directly to his prey by the puffs of white smoke from bursting antiaircraft shells. It tends to keep bomber formations at high altitudes and to confuse their aim and accuracy. While it is undoubtedly true that skilled bombardment personnel can bomb with great accuracy from any altitude it can reach, each type of plane and each group of pilots will have an optimum altitude, a preferable elevation from which they bomb most effectively. The third great advantage of antiaircraft artillery lies in the fact that it elevates morale of ground forces and of the civil populace. The blast of the guns around London has done much to maintain the morale of the defending forces and the nonmilitary subject.

The greatest limitations to antiaircraft lie in the fact that great quantities of guns and ammunition are necessary. In order to give an important military objective reasonable protection with the use of antiaircraft fire alone, a tremendous number of guns and on inordinate quantity of ammunition is an essential requirement. Inclement weather and darkness also serve to render less potent the barrage from the antiaircraft artillery.

The sensitive sonic antiaircraft detectors developed for the Army soon will be augmented by radio detectors.

Antiaircraft artillery is aided in its night operations by searchlights and listening devices. Searchlight batteries can illuminate bombardment planes at night and can retain them in the illuminated area. It not only guides to their targets friendly fighter aviation, but makes it possible for the ground gunner to locate his target. Listening devices enable the defenders accurately to spot aircraft long before they normally can be picked up.

A form of antiaircraft fire which has gained a new respect from airmen, first in France and later in England, is the 50-caliber and 20 mm. automatic weapons. Thirty-caliber machine gun fire and even rifle fire in heavy concentrations is effective against low-flying aircraft. The recognition of this principle has caused the number of automatic weapons to be greatly increased in all infantry and cavalry units.

Our Infantry School at Ft. Benning and our Cavalry School at Ft. Riley have done much to work out systems for the use of light machine guns and rifle fire against low-flying aviation. Our ground arms now are spending much time in perfecting and instilling in our divisions these practices.

This automatic 37 mm. antiaircraft cannon fires at the rate of 120 rounds per minute and can be set up and firing in 45 seconds.

THE WARNING NET

An indispensable adjunct to all direct counter air force measures is the warning net. It is composed of a well-spaced group of listening posts, scattered over an area, interconnected by telephone and communicating with a central headquarters. The efficient net will have observers so spaced that it is impossible for aircraft to move to the target without being observed. A good warning service will have a system of communication so well established that it can supply instant notification of the location, size and direction of flight of the invading bomber formation. The warning service in England from the coast to London appears very effective. This is undoubtedly attributable to the fact that it was established long before required, its personnel was drilled and trained and its communication lines were direct and effective.

The warning net is necessary to alert antiaircraft artillery so that it can be ready to meet the enemy when he comes within range. A 300 m.p.h. bomber is such a fleeting target that it is very important for antiaircraft to receive the earliest possible advance information of its elevation, direction and speed.

Such a net is an absolute essential to the proper operation of fighter aviation. It takes several minutes for an airplane of the latest type to climb to 20,000 feet. Obviously, the fighter cannot engage the bomber until it has reached the same or a higher elevation. Warning must be given pursuit so that the take-off can occur several minutes prior to the arrival of the

Heavy antiaircraft guns like this, for use against high-flying bombers, can shoot to 30,000 feet.

enemy formation at the point selected as the target.

Several maneuvers have been held in this country within the past few years which have afforded extensive practice in temporary warning-net installations. Undoubtedly one of the early tasks of the Air Defense Command will be the establishment of permanent warning services from our coasts inland toward all our vital objectives.

BARRAGE BALLOONS

Prevalence of barrage balloons in large numbers in a limited area tends to keep bombardment aviation away or at altitudes above the ceiling of the balloons. The cables suspended from barrage balloons can and do wreck aircraft. The principal handicap of the barrage balloon is the same as that for the antiaircraft artillery weapon. It must be present in such enormous quantity in order to be effective that it is not always economical.

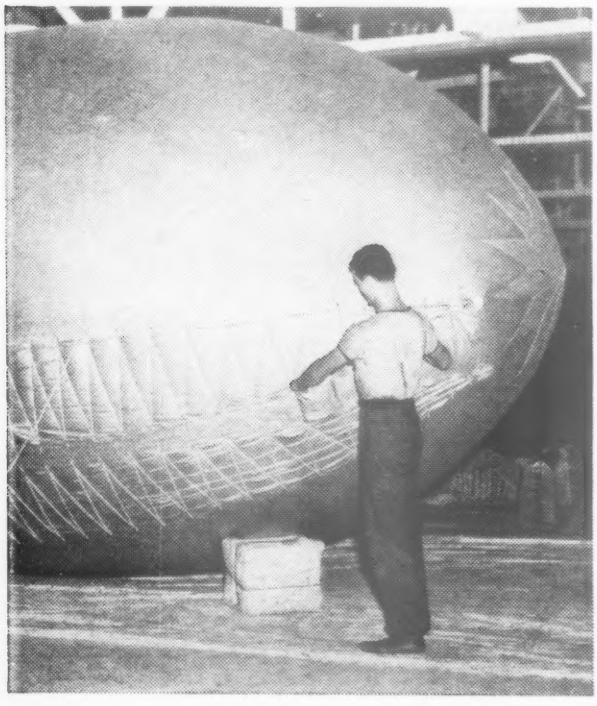
Our Army is preparing to test out thoroughly the barrage balloon as an antiaircraft defensive measure. From our present vantage point it appears that it is a weapon of limited application. It cannot be relied upon entirely for the defense of an area, but it has definite advantages as a co-operative measure.

The ideal situation for the employment of barrage balloons is for installation in concentric rings about absolutely vital targets of small area which must be defended. When the weather conspires to assist, as for example, when there is a 5,000 or 6,000-foot overcast of considerable depth, the barrage balloon can be raised into the clouds and be invisible to the attacking aerial formations. In such a case the damage to invading aircraft is likely to be heavy.

However, if the overcast is thin and the barrage balloon personnel allow the balloon to stick through the top, opposing pursuit can pick them like daisies. In this case the miles of cable come tumbling back on the barrage balloon winch crew.

The best information to date leads to the conclusion that the barrage balloon is not to be discarded as ineffective, but that it is to be used for the imperative defense of small installations of priceless importance. It would be impossible, of course, to supply enough balloons, cables, trucks and personnel to offer any reasonable measure of security to all the important targets in a large country such as ours, where manufacturing establishments, rail terminals and other inviting targets are numerous and widely scattered.

Barrage balloons shown below being inflated were developed in England, now are being made in large numbers for the U. S. Army.



INDIRECT DEFENSIVE METHODS

CAMOUFLAGE

A method of protection against aircraft which has been all too generally overlooked both abroad and in this country lies in camouflage. The art probably has reached its highest development in Germany. Several months before September, 1939, an American observer in flying over the German countryside had several fields pointed out to him. They looked like villages, orchards, roads and many other installations, but not like flying fields. The clever use of the art of camouflage can for a limited period and until broken down by color photography or by experimental bombing, lend a considerable measure of protection.

Camouflage is particularly effective as a protective measure for aircraft factories, munitions plants and other fixed installations which cannot be moved and must be concealed or covered.

UNDERGROUND SHELTER

The best protection against aerial bombardment, of course, is underground shelter. It has economic limitations, however, and there are some places where it cannot be used. Obviously it is impossible to use underground cover for transportation when in motion, such as ships at sea, railroads on tracks and truck transportation on highways. The best principle to follow, apparently, is to provide for underground installations wherever the attack is so imminent and the target is so valuable that it is worth the expenditure of considerable time, effort and funds to render it inviolate.

BLACKOUTS

Bombardment aviation can readily locate illuminated targets at night. The night bomber is guided unerringly to great cities by the illumination in the heavens.

The principal European cities have now had several years of practice and, of late, nightly trials in the blacking out. Street illumination can be controlled from a central source and operated by military personnel as a part of the defense command. To be effective, however, blackouts must have the wholehearted co-operation of the whole civil populace, and it generally requires the strong arm of the law to insure 100 per cent compliance throughout a community.

A string of automobile headlights on a highway or on a street divulges human habitation quicker on a dark night than when the landscape is partially lighted. The lights from shops, factories and private dwellings must be hidden from view by drawn shades, or switches must be thrown if a city is to be blacked out. Shutters are more effective than shades and many new establishments, particularly aircraft factories and other essential munitions manufacturing plants, are being completely equipped with a system of venetian blinds so that they can be completely darkened to outside view.

Co-operative blackouts are ineffective. A city or an area will not be completely blacked out until there has been long practice and with the strict enforcement of definite regulations. It requires a trained and perhaps a frightened populace to make this measure entirely effective.

CIVIL MORALE

An unmeasurable factor of tremendous importance in withstanding the air onslaught is what we may term civil morale. If one who had stood in the streets of Barcelona or in the streets of Warsaw when the German Stukas charged, could now stand in Trafalgar Square in London, quite likely he would be able to define civil morale. It has long been known that the courage of soldiers on the firing lines is greatly affected by the hunger or the sickness or the endangering of their families far behind the lines. One of the devastating innovations of air attack is its ability to bring that pressure. A stout-hearted civil populace will be a tremendous factor in the success of any nation to withstand heavy and continued air raids.

The government can have an important influence on civil morale in several marked ways. One is by the provision of adequate air-raid shelters and an effective warning system. Another is in a propaganda or public information campaign to inflame the civil populace to a firm belief in the rightness of their cause and to a hatred or scorn for the attacker. Another is by instilling into a people the conviction that their cause will prevail, that they are being well led and that victory is inevitable. They must also be shown clearly that the sacrifice is worth the cost.

The morale of a civil population, like most things, is the result of planning and organization. A whole territory must be laid off into small sections; alert leadership must be selected and designated duties and functions according to a prearranged plan. There must be local organizations for fire fighting, hospitalization, medical care, air-raid warnings and for building, street and communications repair.

Finally, this organization must be drilled until every required action is reduced to routine. People do not act normally when bombs are falling. If they have been well taught and well trained and well led, they will habitually do the right thing and the result will be high morale and a stout defense which may be of great help in winning the war.

Chapter Eight
AIRCRAFT PRODUCTION

"I have long known that while in warfare the heartaches will be on the firing line, the headaches will be on the production line."

—Louis Johnson

THE three gauges for the air strength of a nation are: air force in being; reserves of planes and combat crews; and productive capacity for airplanes and trained personnel. The last of these is by no means the least. A nation likely and able to win a war will enter it not only with the largest and most efficient air force, but behind that first line will stand the second line, the ability to maintain that superior strength in men and machines.

Several things determine and proscribe the aviation production capacity of a nation. The most important of these include raw materials, manufacturing plants, machine tools, skilled workmen, supervisory personnel in plants, appropriations or capital, and national will, sometimes called national policy. The United States is superlatively endowed in the first four of these essentials. It possesses more of the necessary raw materials than any nation of the world. While its aeronautical industry is not as large as some of the warring nations, it has the capacity for building these facilities in greater proportion than any other nation. While it does not now have as many experienced workmen in aircraft plants as Germany, it undoubtedly has men with equal aptitude and probably greater; it has a class of labor, skilled and unskilled, which can be more quickly trained. It has a pool of man power more familiar with mass-production methods than any found anywhere else in the world.

Until relatively recent times, the great handicap to the provision of a large and thriving aeronautical industry in this country suitable for the modern needs for a war reserve has been the lack of suitable appropriations for plants. The Federal government appropriated less than $25,000,000 annually over a long period of years for the procurement of military aircraft. Civil capital was not attracted to the aircraft industry because it did not appear there would be a great enough demand to warrant large capital investments, since there were no airplane consumers of any consequence except the Army and Navy.

Now, as to national policy—the will of the nation and its leaders—which is in reality the crux of the matter. The United States until 1939 had no strong nor definite policy favorable to the building up of a great aviation industry. Our nation has always been traditionally peace loving. Its military policy has always been one of defense. The great majority of the people who thought on the subject at all, considered long-range air weapons as offensive weapons, when our military policy was a defensive one, and were therefore lukewarm, if not cold, to their production in quantity.

During one brief period in our history, the first World War, we had earnestly and ardently desired to produce airplanes in quantity and we had bent our national will and effort toward that end. During that period we built our industry from almost microscopic proportions to a point where it was able to produce within a little more than 18 months, 20,000 planes and 32,000 engines, or the equivalent of 8,000 1,000 h.p. engines. At the conclusion of that period, however, misguidedly believing we had made the world safe against destructive aggressive forces for all time, that great aviation industry was allowed to disintegrate.

Several factors late in 1938 induced this nation under the able leadership and aggressive direction of its President to set about increasing its aircraft industry. As a result of the Chief Executive's 1939 message to the Congress, an appropriation of $170,000,000 was made immediately for the procurement of 3,000 additional modern planes for the Army, of which more than 1,600 were to be of the latest combat types, this to give the Army a total plane strength of 5,500.

To the prerequisites essential for a great aircraft industry—raw materials, factory capacity and skilled labor—were thus added the remaining essentials, funds and a national will or policy, a determination to build a greater air force.

That was the picture by midsummer, 1939. Sept. 1 Germany invaded Poland. Sept. 3 England and France declared war on Germany. The Polish campaign demonstrated unmistakably that air forces had added a third dimension to warfare; that a new fighting force had come to join armies and navies to control the destiny of nations. Small nations with little air forces fell with remarkable ease and startling rapidity to the crushing combination of air forces and mechanized, motorized divisions.

These startling international events indicated further revisions of our air strength on a rapidly rising curve. Three supplemental estimates to the regular appropriation bill for 1940, which had provided less than 200 airplanes for replacements, were passed by the 76th Congress. These authorizations swelled unfilled orders of planes for the Army to some 21,000, a peak procurement requirement for all time.

Appropriations were made increasing the Navy's total strength by about 6,000. Foreign orders which had been placed with the aircraft industry for about 12,000 planes, made a total requirement suddenly thrust upon the aircraft industry of about 40,000 new planes, about half of which were of combat types. Fortunately for the industry, however, the orders for the Army's first 3,000 had been placed 12 months earlier than the others and production was well under way. Training planes were rolling out of the factories by hundreds each month.

The national will was suddenly alive. It decided, in the slow but normal American manner, that money being the answer to everything, appropriations for $2,000,000,000 would insure the instant creation of a new and powerful air force.

Man power suddenly jumped from 32,000 men employed in the production of aircraft in 1939 to 125,000 by September, 1940, and it was quite evident, with the rate of training in progress, that skilled man power would not prove a serious bottleneck. There was a real problem in delivery of machine tools. We had not speeded up our production along that line to meet requirements and deliveries for the larger and more complicated machines could not be secured for periods of from six to nine months after orders were placed.

United States appropriations totaling almost $2,000,000,000, plus foreign purchases of an additional billion, stimulated the industry, but facilities were not ready to absorb the orders. We found that there was really no substitute for time. There was a shortage of aeronautical engineers and it requires time to train them. Supervisory and administrative personnel for factories cannot be picked up overnight. Six to nine months

are required to build and equip new aircraft factories.

The American industry came through, as it usually does, and built up a firm base—then the superstructure—and now is showing the results of careful planning. We are on our way.

The American aircraft industry from the time the Wright brothers built their first frail craft, including the production for the first World War, during the whole 36 years of its existence, had been required to build less than 45,000 planes. Now it was asked to deliver, within a period of two years, nearly this total with all the modern improvements and complications of design.

Raising the aircraft production capacity from less than 1,000 planes per year during the lean years in aviation—the twenties and thirties—to 3,600 military planes per month is a many-sided problem. Here are a few of the factors involved:

(1) Time
(2) Air frame production facilities
(3) Engines, instruments, and accessories production facilities
(4) Skilled labor
(5) Co-ordination of foreign orders with production for our own military services and commercial needs
(6) Co-ordination of foreign deliveries schedules
(7) Leadership, civil and military, and executive control
(8) Legal and fiscal problems
(9) Military requirements as to numbers and types
(10) Maintenance of production capacity

AIR FRAME FACILITIES

In 1938, the last normal year, aviation factory capacity was approximately 5,000,000 square feet, with about 27,000 workmen employed in airplane construction. There were an additional 7,000 working on engine production. During that year 3,675 planes of all types were built. Of these 150 were transport planes, 30 private planes, 1,425 lightplanes and 1,800 military planes, including those produced for export. With this base, the industry agreed that it could step up production to meet the 5,500 plane program of the Army and at the same time take care of the Navy's and foreign business then in prospect, without any tremendous expansion in floor space and factory facilities. It could do this, it contended, by adding two eight-hour shifts. It had been for the most part theretofore on the one-shift-per-day basis.

In the summer of 1939, the Chief of Air Corps, after careful survey of the capacity of the industry by military aviation experts, was able to tell the Congress that he expected the American aircraft industry to be able to reach a production of 1,200 planes per month by October, 1940. Some in the industry felt that this figure was much too low. The total actual production for the month of October, 1940, was 1,170 planes.

There was much discussion before Congress and between Army and Navy and industrial leaders as to the possible methods for reaching, in the quickest possible time, the necessary plant expansion required. Three plans were carefully weighed. The first was to leave the plant expansion entirely to private industry. The second was to have the plant expansion built by the Government. The third method was to have the Government build the additional plant facilities required and to have them operated by private enterprises.

The one eventually selected was the compromise plan, although there have been some instances of the employment of all three methods. For the most part, the principal establishments have built their factory additions with funds lent by the Government, but to be operated by private industry. At the close of 1940, production not having reached the rate of speed-up desired, there was serious discussion of building at least two exclusively Government-owned plants of vast size, to be operated either by aircraft industry management or by the automobile industry.

By late summer of 1940, aircraft production had become a political issue. There were charges that the civil aircraft industry had sat down in the road and refused to budge until excess profit limitations had been erased from the statutes and other Governmental assurances given.

The Assistant Secretary of War, the Honorable Louis Johnson, answered these critics in this fashion:

"American industry has co-operated and is co-operating with us wholeheartedly in our industrial mobilization planning. The War Department has taken the initiative and our industrial leaders have responded. Patriotism is not the exclusive possession of the fighting man. The worker and the factory manager have shown that they too realize their responsibilities and the import of their post-wartime tasks."

This much is now certain. The American aircraft industry was, as 1940 drew toward year end, well under way toward making the necessary plant expansion to reach an aircraft production capacity of at least 2,600 planes per month no later than the fall of 1941 and 3,600 by the fall of 1942. That is a remarkable increase, an increase of 25 times, bearing in mind that the monthly production average for the 10 years succeeding 1920 was less than 100 planes a month.

SKILLED LABOR

When the demand for the phenomenal increase in aircraft production became evident in the summer of 1939, many felt that skilled labor would prove the neck of the bottle. Starting with less than 35,000 employes in our airplane and engine factories, we had reached by the late fall of 1940 a total employment in these industries of over 150,000.

Our manufacturers were employing the apprentice system. High school graduates and graduates of technical schools were placed beside trained employees as understudies, both in the airplane and in the engine factories. It is now apparent that this system will prove entirely effective.

THE TIME FACTOR

Time is an essential factor in preparedness for war. Since 1939, despite the most thoroughgoing effort of the Government and industry to co-operate in raising the production level of military aircraft, we now find, more than a year after the genesis of that effort, a production capacity of only about 1,200 planes per month.

It takes more than 100,000 man hours to build and equip a modern *Flying Fortress;* 12,000 for the average plane. Multiply this figure by 25,000 airplanes per year and there is a time and labor total which is staggering.

This is the basic reason why air forces must be in being when a war starts. There will not be time after the bombs begin to fall to build either the factories or the planes for the creation of a larger air force. All the time and all the facilities will be required to maintain the air force with which we start at its initial strength.

CO-ORDINATION OF FOREIGN ORDERS WITH PRODUCTION FOR OUR OWN MILITARY SERVICE

There has been considerable discussion concerning foreign plane orders. Some have contended we should build up our own air force first. Others have thought that we should delay building our own air force until England is supplied with all she needs to fight the Battle of Britain.

The release policy for foreign sales was explained by Colonel Louis Johnson, Assistant Secretary of War, as follows:

"We will permit our manufacturers to sell to foreign buyers our late models of aircraft and engines and they will receive in turn not only an adequate monetary compensation, but we will get improved planes for our own air force and an aviation industry capable of producing them in quantities required. In addition, we shall receive promptly the latest information from foreign proving grounds, technical and tactical information vital to our own war plans.

"There will be no delay in the delivery of sufficient military aircraft to equip our own air force adequately and to arm our own squadrons. We shall permit a reasonable delay in the delivery of some of our reserve airplanes in order to incorporate in them the necessary changes to make them superior fighting aircraft. It is a fair exchange—one of those fortunate bargains where both sides gain their desired ends. Our foreign customers get the planes they desire when they

View of Curtiss factory showing mass production of P-40 pursuits under stimulus of emergency conditions. Although production is over 10 planes a day, lack of engines sometimes delays delivery.

need them; our industry is built with foreign capital to the proper size and our air force is equipped with superior combat planes."

To amplify, let us assume that the British Purchasing Commission desires light bombers from the Douglas Company of a similar type to those now being produced for our own Army Air Corps. Our Government authorizes the British to have them after sufficient have been produced to equip all of our light bombardment squadrons. Let us assume that it takes 200 light bombers to equip our squadrons. When the production has reached the 200th bomber, the British order cuts in. It takes its quota and then the ensuing number are our light bombers for our reserve.

From the standpoint of the size and efficiency of our civil aircraft industry, it has been fortunate for us that several of the foreign nations have been forced by the inadequacy of their own aircraft industry to come to us with plane orders.

CIVIL AND MILITARY CONTROL AND LEADERSHIP

In industry, as in military operations on the battlefield, a definite plan with bold leadership is a principal requirement. When the present emergency at first became apparent, leaders in civil industry were assembled at the request of the War Department to perfect a definite plan. Soon thereafter the Chief Executive appointed a National Defense Commission of outstanding industrial and labor leaders, to serve in an advisory capacity and for liaison purposes between capital, industry, labor and the Government consumers. Excellent results have been obtained. The Commission has co-operated wholeheartedly with the Army Air Corps and has shown no disposition to dictate types or requirements, or otherwise to infringe upon the responsibility of the military. The labor leaders in the Commission have rendered indispensable service in the avoidance of damaging strikes in aircraft and munitions factories.

There is always a danger in instituting a new organization to meet a national crisis. Too often it makes for confusion and there is always the possibility that in its desire to secure standardization and production, it will freeze types and thus prevent changes necessary to achieve the performance dictated by combat. Such an organization also breaks down routine and established procedure. It speaks volumes for the quality of industrial and military leadership that the creation of the National Defense Commission and the necessary changes in the procurement procedure as a result of the formation of the new commission have not had these effects.

There has been much discussion as to whether Government plants, Government owned and operated, should provide the additional facilities and establishments required for increased wartime production. Those favoring this method contend that these additional establishments could be closed promptly at the end of the war or emergency period and the civil industry would not be faced with the serious deflation which normally occurs when the war emergency is over. The opponents to that system have contended that Government ownership of aircraft factories is a new departure and a dangerous precedent. They have contended that the Government does not possess the skilled engineers and designers and industrial management requisite to the operation of such plants. This latter contention is undoubtedly true. At present it appears that the system which in general will be followed is a co-operative give and take whereby the Federal Government builds the plant only when private industry does not desire to do it. In all cases the augmented establishments will be operated by an old and established manufacturing institution.

LEGAL AND FISCAL PROBLEMS

In the summer of 1940, there was a delay of several months in construction of plant expansion in several of the older and larger aircraft factories. It was charged in some quarters that this showed an improper spirit on the part of industry, a failure to co-operate, a desire to hold a club over the Government in time of emergency, a demand for excess profits. Actually this delay was taken by the companies to

Clearly evident in all major aircraft factories are the stepped-up production lines like these at Douglas which is turning out hundreds of A-20A and DB-7 light bombers for the U. S. and British.

await additional pending legislation and for the pronouncement of certain legal decisions on amortization and tax matters which would enable them to arrange their finances. The passage by Congress and the signing by the President of the tax legislation cleared up this difficulty in September, 1940. With the passage of excess profit legislation and the pronouncement by the Treasury Department of the exact status on amortization and tax structure, the 90-day delay was at an end. By November, 1940, contracts had nearly all been signed and plans completed for all proposed expansion.

HOW CAN MAXIMUM CAPACITY BE MAINTAINED AFTER IT HAS BEEN REACHED?

The Chief of Air Corps recommended to the War Department in the fall of 1940 that it would be impossible to reach and maintain maximum production in the aircraft industry without definite assurance of what business was to follow. An airplane factory could not well enlist a pay roll of 10,000 employees and build 500,000 or 1,000,000 square feet of additional floor space, required to complete a plane order in six months or a year, with no prospect in sight for work for this great factory or its employees at the end of that period.

Funds have been appropriated for the delivery of 21,000 Army planes by July, 1942. If the American aircraft industry is to maintain a production rate of 36,000 planes per year, it will be necessary for Congress to provide funds for many planes for the fiscal year 1943. How much of the productive capacity must be kept in operation if we are to have its maximum available when we need it at some unknown date in the future? The great danger is that some sudden cessation of hostilities or some impending peace trends may lead the public mind to provide inadequate funds to maintain the production capacity which has been so difficult to obtain.

Obviously, an aircraft production capacity of 36,000 planes per year cannot be maintained indefinitely, involving as it does a cost to the Government of a billion dollars per year.

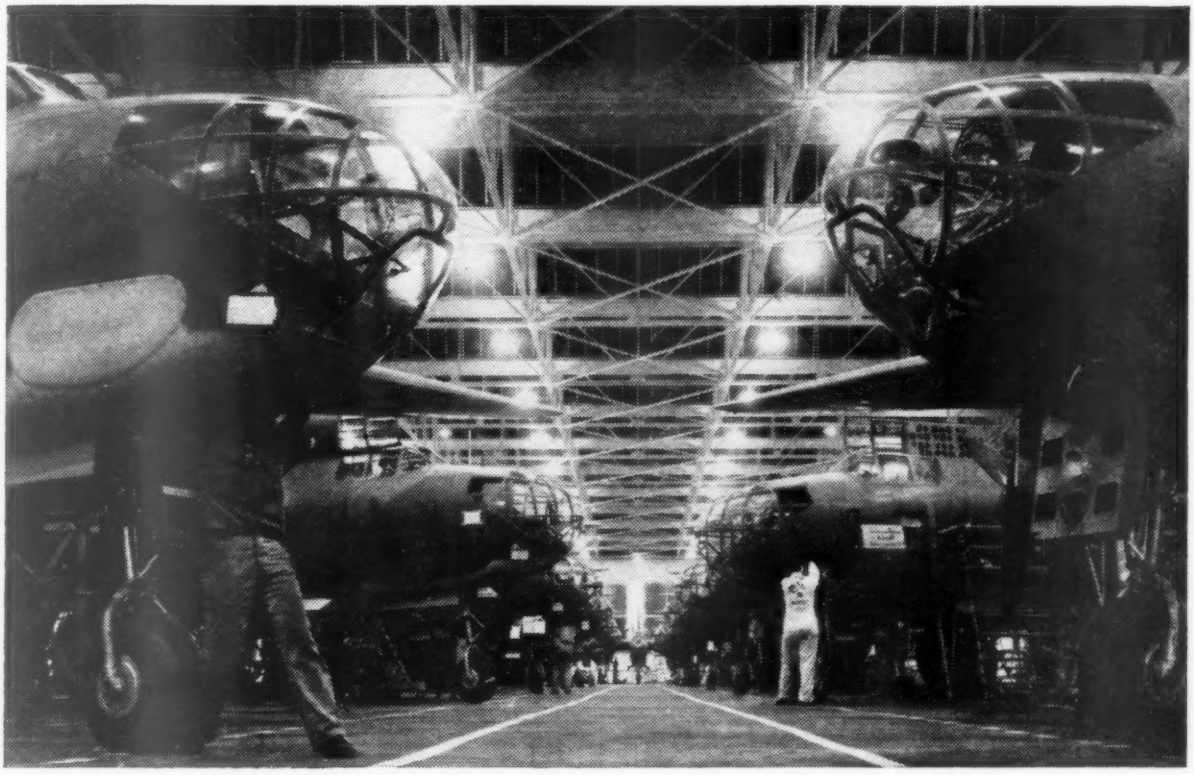
Serious economic questions will confront the nation as to how to dispose of the surplus. Some have suggested that the field of hemisphere defense will be a part of the answer. Most certainly if we have a large reserve of planes, it would seem to be a far better plan to sell at a reduced price to our South American neighbors than to have them become unusable standing on our flying fields.

If a period of peace and international stability should settle upon the world, the great aviation production capacity in Germany and in England will search diligently for foreign markets. It is fairly definite that both of those nations, wise from the experience of recurrent wars, will not wish to allow their aircraft-manufacturing establishments to disintegrate and decay. This is a problem which our Government and our aviation industry should now attack with all the intelligence they command.

The truth of the matter is that a nation which builds definitely toward a war at a given time has a definite advantage over a peace-loving nation with a defensive military policy. It will require greater diplomatic acumen in the future if nations peacefully inclined are to survive. It takes time to build airplane production capacity, time to build air forces; therefore, it is imperative either to know when war will come, or to know when enemies begin to prepare for war.

MILITARY PLANE REQUIREMENTS AS TO NUMBERS AND TYPES

One of the first determinations to be made when a nation decides to build an aircraft industry and an air force is to arrive at an intelligent conclusion as to the types of planes needed and to reduce these to the smallest possible number of types. It is much easier to build 1,000 planes of a single type than to build 100 each of 10 types. On the other hand, it has been conclusively proven that we have not yet reached the happy day of the all-purpose airplane. Military require-



These British "Bostons" and U. S. A-20A's at Douglas plant are evidence of increased production. Big problem has been in getting engine and propeller plants geared to plane output of aircraft companies.

ments demand several types of fighters and several types of bombers. An ineffective air force will be provided if ease and speed of manufacture only are accepted as the criteria. Likewise, there will be delays in the production of aircraft if there be indecisiveness as to types and quantities of each type required. Types must be frozen as far as changes are concerned for production of a definite number of planes. Then the advantages of changes must be weighed against the loss in production.

Military leadership must always make the determination based on military requirements and necessity as to the types of planes which are to be built; no one else can do it. The National Defense Advisory Committee has been wise, indeed, in refraining from attempting to exercise any determination over the types of planes to be built. At one time in our recent military history the development of the heavy bomber was quite definitely opposed. Since our national policy was one of defense, attempts were made to meet our requirements with medium and light bombers and pursuit aircraft only. That might have been a serious, almost a tragic blunder. Both Germany and England delayed the building of large four-engine bombers too long, by their present admission, and are now frantically engaged in making good those arrears.

CO-ORDINATION OF FOREIGN DELIVERY SCHEDULES

In a nation such as ours where the factories of our aircraft industry are engaged in the production of foreign orders as well as those for our own military establishments and where the foreign buyers are hard pressed in battle, there will always be an insistent demand to forego delivery to our own military forces in favor of those hard-pressed foreign purchasers. An executive decision must be made after a careful study of the diplomatic and international situation as to the proper course to pursue. Our own involvement, the time when our air force may possibly be required either for fighting or to influence other countries in international negotiations, are two determining factors. A faulty guess or unsound reasoning may mean national disaster during future years.

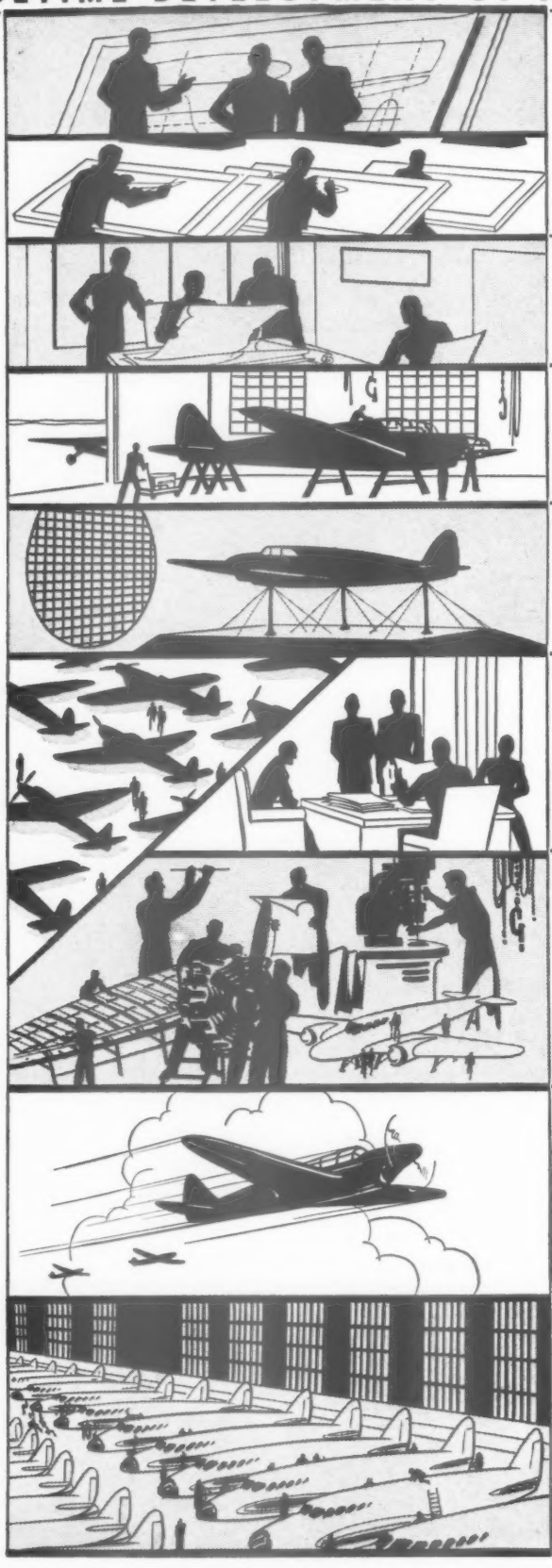
It has been suggested that the aircraft industry in the United States has or will conspire with the foreign purchaser to give him priority of delivery because of greater profits which can be expected from foreign orders. There is no evidence to date that the leaders in our aircraft industry have been unpatriotic in this regard.

PRODUCTION FACILITIES

The most serious bottlenecks in the aircraft industry have not been in airplane production but in some of the vital accessories, particularly in the engine field. When our own expansion increased the annual engine demand from 3,000 to 30,000 engines, with thousands under contract for foreign delivery, it soon became apparent that many planes would be held up on the production lines for want of suitable power plants. The National Advisory Commission for Defense has co-operated mightily with the War Department in an effort to solve this serious problem. There has been great expansion in the old airplane engine companies and an effort has been made to extend the facilities of some of the minor companies to provide for larger engines and to induce automobile manufacturers to enter this field. However, it will be at least two years before engines will be available for all the planes rolling out of the factory doors.

Delivery on many of our military airplanes may possibly be held up for shortages in some of the vital instruments and accessories. There is very little civil demand for many of these products and the expansion to meet the greatly augmented military requirements is approached cautiously because of the consequent deflation which may occur when the emergency no longer exists. Here it is necessary for the Federal Government to intervene promptly and order and pay for the necessary expansion for the instruments, the armament, the radio and other accessory equipment vital to the production of the completed fighting plane.

PEACETIME DEVELOPMENT OF A MILITARY AIRPLANE



JAN. 1, 1938

MILITARY ASPECTS OF NEW PLANE APPROVED. MAKERS PREPARE BIDS.

EVALUATION OF DESIGN AND AWARD OF CONTRACT TO WINNING COMPANY.

JAN. 1, 1939

CONSTRUCTION OF ONE EXPERIMENTAL PLANE.

JAN. 1, 1940

FIRST PLANE TESTED. CHANGES MADE BY THE ENGINEERING SECTION.

JAN. 1, 1941

UP TO 13 PLANES DELIVERED. DESIGN OF COMPETING PLANE BEGUN.

DESIGN COMPETITION DECIDED. FINAL CONTRACT WILL GO TO WINNER.

JAN. 1, 1942

TEST AND EVALUATION OF COMPETING PLANES. PRODUCTION CONTRACT LET.

JAN. 1, 1943

PRODUCTION OF AIRPLANE IN QUANTITY UNDER WAY.

THE PRODUCTION OF A MILITARY AIRPLANE

There are definite steps in the production of the military airplane and these are in a regular sequence and each has an important time element.

The first phase is the experimental period. A designer has a vision. He reduces these ideas to drawings. The drawings, when completed, are submitted for analysis to the experimental section at the Matériel Division, Wright Field, to determine whether the new plane represents a sufficient advance and is desired by the Air Corps as a new plane type. If found to have merit and if planes of that type are desired, a proposal is made and widely publicized to the industry for a new plane having the characteristics and performance desired. Care must be taken in all of our dealings that we never knowingly or unknowingly disclose any confidential information received from a manufacturer. All manufacturers who believe they can comply with our requirements and specifications submit designs. An evaluation is then made and the best of the types is selected for order. The experimental contract is then let.

A minimum of from three to five months will have elapsed in arriving at the determinations, the issue of proposals, the examination of bids and the letting of the experimental contract.

The winning manufacturer then begins to build the experimental article. Since there is but one of the type and since it represents a new departure, it will be in all essential regards a handmade article. It will require, for the simplest type, the single-seater fighter, at least six months to build this experimental plane. For the heavy bomber or multi-engine fighter from nine months to a year will generally elapse.

This experimental plane is then flown from the factory for flight test at the Matériel Division. The test pilots flight check it for performance and airworthiness. The aeronautical engineers examine it for strength factors, arrangement of armament, as to suitability for combat crew operation, and to determine whether it meets with the terms of the bid. This third examination or acceptance phase will require an additional 60 to 90 days. Thus, nearly two years have elapsed in the building and testing of the first airplane, the experimental model.

A second or production contract is then let as a result of proposals and bids from all manufacturers who have the facility to build a plane of that type. The winning bidder then is given a contract for a definite quantity, as required. Another period of one year to 18 months will be required for the production of the order. Thus, it requires, in peacetime, from three to five years to produce a military airplane in sufficient quantity to arm the fighting units with an appreciable number.

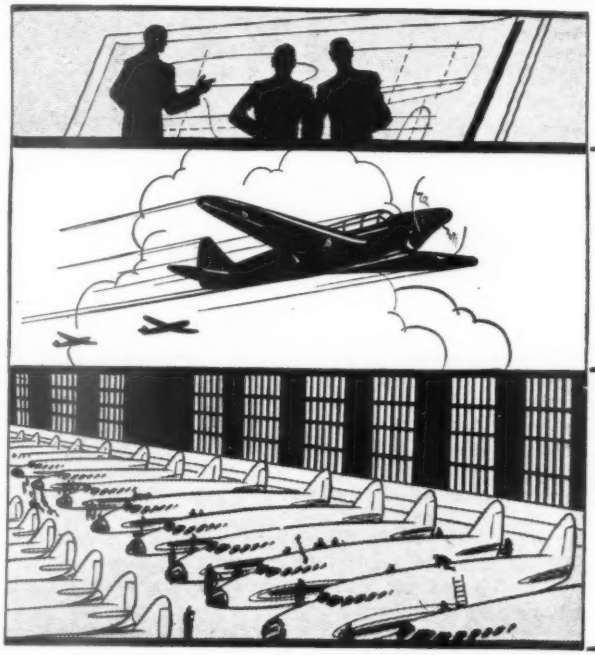
In time of war or national emergency every possible effort is made to abbreviate these periods. It probably will never be possible, however, to produce a new type in large numbers in less than two years and it will generally take longer, particularly for the larger types of aircraft.

EXPERIENCES FROM ABROAD

One disturbing factor which will always be injected into American aircraft production, both in times of peace and during war, is the question of changes. The British industry has accomplished miracles in this respect. The manufacturers may be in the middle of the period outlined in the foregoing section. The experimental plane will have just been produced and flown, or the first 100 of the production order will have been built when it will be discovered that the type is not entirely satisfactory because it should have a 20 mm. gun instead of a 30 caliber, or there should be better visibility for the pilots, or it should carry bombs or have bulletproof tanks. It will be necessary then to stop production, redesign the tanks, or the armament, or the armor, throw out the old tanks and fit in the new before the production flow can continue.

There is always an executive determination to decide whether the new changes recommended are sufficiently important for the delay they will cause. Generally, it is wise to pursue a middle course, eliminate all changes which are

WARTIME DEVELOPMENT OF A MILITARY AIRPLANE

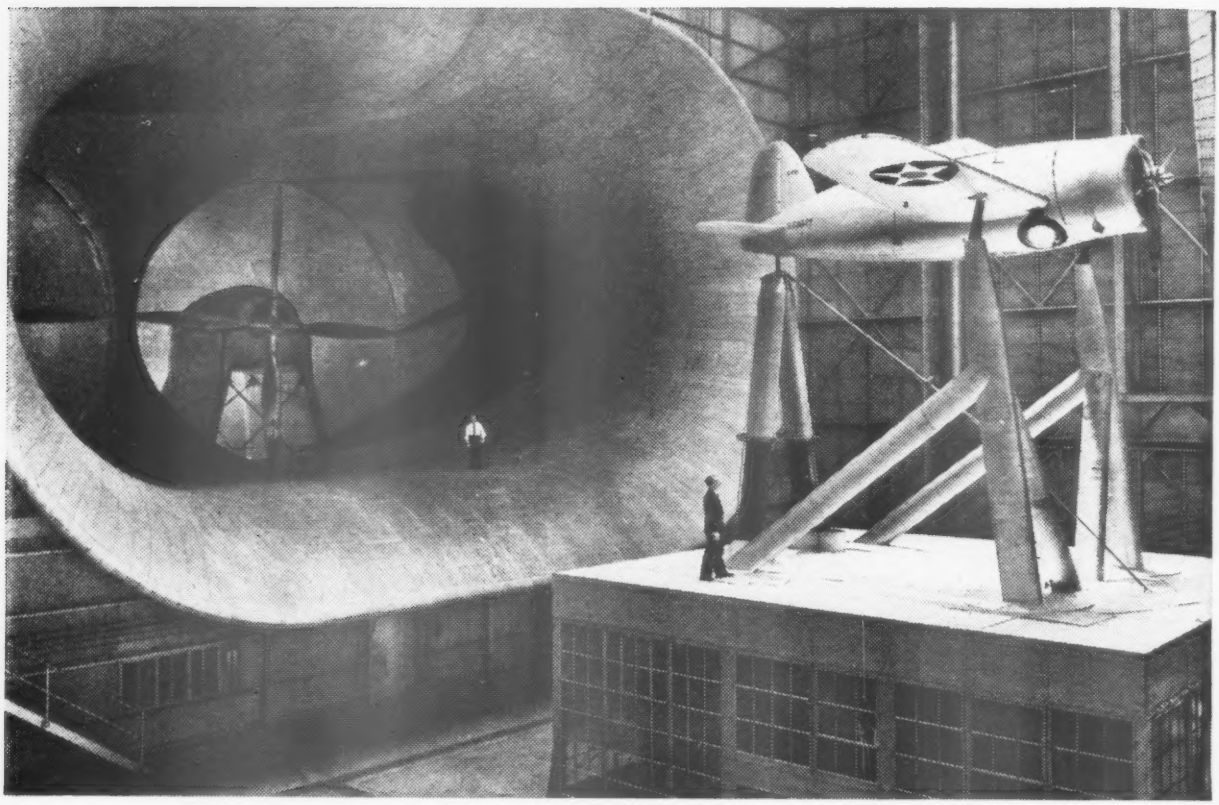


ONE YEAR

MILITARY DEMANDS UPON NEW PLANE EXPLAINED TO EXPERIENCED BUILDERS.

NEW PLANE DESIGNED AND BUILT BY MANUFACTURER. ARMY GIVES PROMPT TESTS.

QUANTITY PRODUCTION BEGUN IMMEDIATELY. DESIGN FROZEN AGAINST CHANGE.



This is the largest wind tunnel in the world, big enough to test full-size airplanes such as this Navy Brewster XF2A-2. Operated by the N.A.C.A., it is a vital part of U. S. research facilities.

not absolutely essential in order to enable the new airplane to live under the battle conditions it will meet.

In England the Supermarine *Spitfire*, although ordered from the drawing-board model late in 1934, was still in the experimental stage in 1938, and only the prototype had been flown. Some observers report that despite the great emphasis in England on aircraft production, including the tryout of the shadow factory scheme, her production was about 2,000 planes per month late in 1940.

It is unlikely, German observers state, that France's strike-ridden aircraft industry ever reached a production of 1,000 planes per month. These facts should be borne in mind by the critics of our own industry who are now impatient of the efforts being made to reach in a period of two years a production capacity of 36,000 planes per year.

In our effort two considerations must be borne in mind. If we entered a war there would be no industry anywhere in the world, upon which we could draw save our own. The other factor which we must never forget is this: England worked under supreme pressure and at maximum effort and in more than four years was able to get a production rate of about 2,000 planes per month.

Air forces are thus limited by the size and efficiency of the manufacturing establishments and the plane production capacity. The strength of our air force, therefore, has two limitations: first, the requirements for our own protection and for hemisphere defense; and second, the maximum capacity of our industry. If the latter can be built to meet the former and maintain it in a fierce struggle against equal adversaries, it will likely mean victory and a hard-won peace. If we cannot accomplish those desirable ends, it will mean defeat and all that entails, if, indeed, air forces have come to be the decisive factor in warfare, as many now believe, and as the tide of battles now raging seems to indicate.

Chapter Nine

AERONAUTICAL RESEARCH, EXPERIMENTATION AND DEVELOPMENT

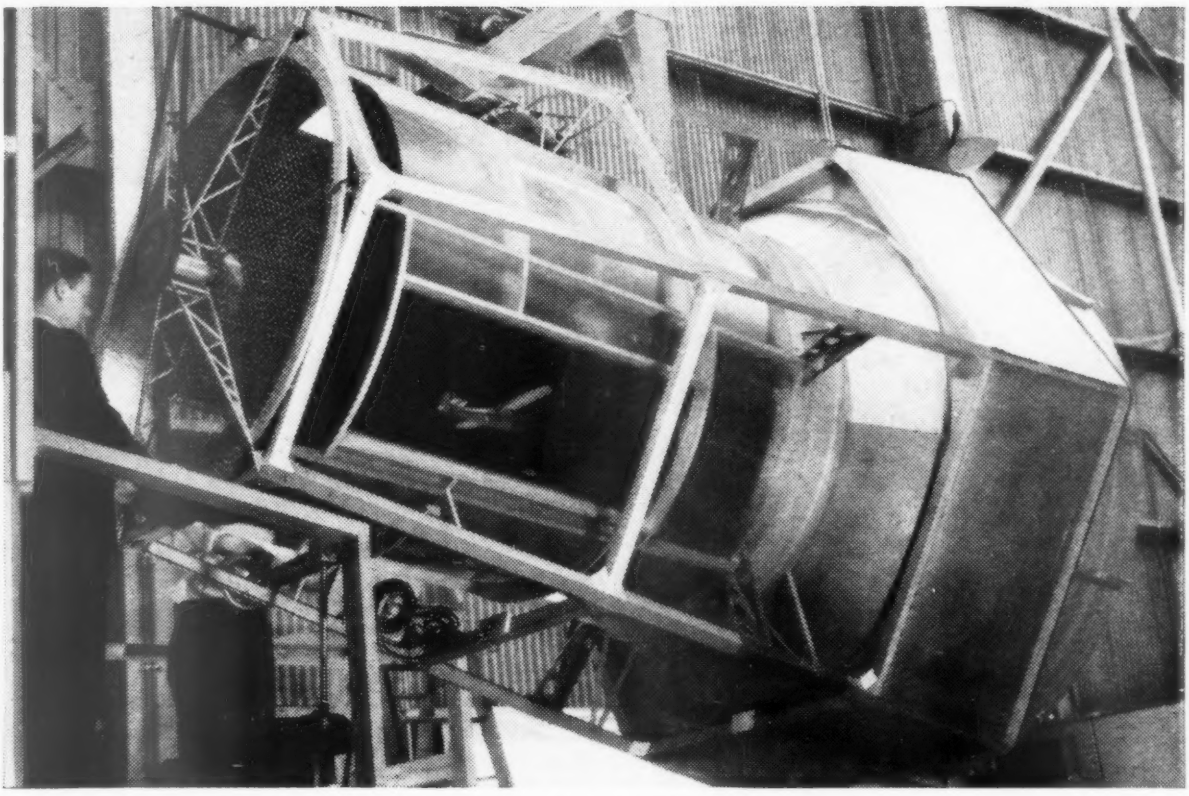
"Research is the reconnaissance party of industry, roving the unknown territories ahead, indefinite yet not without purpose, seeing for the first time things that all the following world will see a few years hence."

—S. M. Kintner

AIRPLANES, unlike the Greek mythological weapons, do not spring full blown from the head of Jove. No airplane, with its instruments essential to air navigation and its guns and bombs, takes off from mother earth and points its nose skyward until it has been conceived by the dreamer, until drawings have been made by the designer and until it has been fabricated by the expert builder and tested by scientific specialists. There are important trinities in aviation progress. There is the trio of the laboratory, the workshop and the test pilot, which conceive and build and fly the experimental plane. There is the triumvirate of the plane, the engine and the accessories, which go to make the flying weapon, but the field of research and experimentation covers the whole subject of scientific development like a circus tent.

Research has been defined as a systematic investigation of some phenomenon or series of phenomena by the experimental method, to discover facts or co-ordinate them as laws. This is a dry definition which fulfills the requirements of the scientist, but the air forces of the world today are interested in the objective results of the mathematician, the physicist, the aeronautical designer, the aviation engineer and the skilled craftsman in the factory. There is a dramatic, objective quality when a sleek, new, metal fighter rolls from a factory door, climbs like a rocket and streaks through the air. That is dynamic, that is a visible accomplishment which writes its own headlines.

Too frequently the tedious and painstaking work of the



Task facing the N.A.C.A. is to supervise, direct and apply scientific problems of flight. In this "free flight" tunnel at Langley Field, engineers constantly are searching for aerodynamic secrets.

scientist, the fevered brain and the cramped body in some remote laboratory cell, receives little acclaim. There is nothing spectacular or romantic there. So when great pressure is put upon a nation, when an emergency comes, when the war clouds gather, there is a natural, but fatal tendency to cut off support for the laboratory technician, for the designer, for the engineer and put all effort into production.

There is always the tendency that the experimental divisions of the factories be closed so that the skilled workmen and engineers may be taken from experimentation and set to swell the needed additional army of plane builders.

Germany did not make such a mistake. While building the greatest air force the world has yet seen, she maintained the most extensive laboratories and research facilities available to any nation. That accounts for her being able to bring out new models at frequent intervals. That accounts for the fact that she could get up off the floor in 1933 and build superior fighting planes in unheard of quantity by 1939.

In the U. S. we spent three times as much in 1939 on experimental development as for any previous year in our history. There has been appropriated more than twice as much in 1940 for experimental development as was available in 1939. This is a healthy sign and this points to a maintenance of our leadership in quality while we strive for quantity.

Research, experimentation and development require four vital things—objectives, facilities, personnel and money. It is now opportune to review the available resources in this country in these four indispensable regards.

THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

"Public No. 271—63rd Congress, June 30, 1916. . . . . That it shall be the duty of the Advisory Committee for Aeronautics to supervise and direct the scientific study of the problems of flight, with a view to their practical solution, and to determine the problems which should be experimentally attacked, and to discuss their solution and their application to practical questions."

The charge has been broadcast on more than one occasion that there is a duplication of effort between the Army, Navy, the industry and the National Advisory Committee for Aeronautics. The Committee has steadfastly stuck to the task assigned it by the Congress at the time of its creation. Its objectives and efforts are directed and devoted to the problems of fundamental research, leaving to the Army and Navy the task of applying the data obtained to military aircraft and to the civil industry the field of applying these principles to development of new types and to production. An illustration will serve to indicate the narrow line for this theoretical subdivision.

One of the outstanding accomplishments of the National Advisory Committee was the discovery of the effect of turbulent air in the wake of an aerodynamic body. NACA scientists, as a result of wind tunnel experiments, discovered that an engine cover or cowl of particular design smoothed the flow of the air over nine hot cylinders and at the same time improved cooling. The industry and the Army and Navy took the seeds of this discovery and applied them to the building of engine cowlings to fit particular engines, for installation and adaptation to particular planes. The Committee's effort was fundamental research. The effort of the armed services and the civil industry was applied research, development and experimentation with air-cooled installations.

The original home for the National Advisory Committee for Aeronautics, its first laboratories, was established at

Specific job for one laboratory at Wright Field is to test airplane propellers. This is outdoor whirl test rig where props are turned by 6,000 h.p. electric motors for 150-hour endurance test.

Langley Field, Va. During the past year an additional aerodynamic laboratory has been provided for erection at Sunnydale, Cal. In these plants are installed remarkable collections of scientific equipment and there work daily mathematicians, physicists and chemists, wrestling with new problems, looking always ahead, miles ahead, to the airplane coming up six, eight, or 10 years hence.

The National Advisory Committee for Aeronautics has not received the publicity and there is not the general popular knowledge of its accomplishments to which its work, its progress and its success have entitled it. It is an institution essential to the maintenance of our leadership in the flying world. On the economic side, it has paid for the appropriations which have supported it many times over. Its research in spinning characteristics and its spinning tests alone have saved the Army, Navy and civil industry millions of dollars. Its discoveries have been instrumental in adding many miles per hour to the speed of American aircraft. Its discovery of new aerodynamic principles used in propeller design has helped to crack one of the knottiest problems facing the airplane designer. Its contribution to engine experimentation has resulted in recognition of the importance of fundamental research in engine design. The last Congress appropriated $10,000,000 for a new laboratory, the primary purpose of which will be power plant research.

The work and objectives of the laboratories are directed by a committee composed of a group of outstanding scientists and includes also the Chief of Air Corps of the Army and the Chief of the Bureau of Aeronautics of the Navy, the head of the United States Bureau of Standards and the Weather Bureau and outstanding representatives from industry. It now employs about 600 scientists and engineers. With the opening of the new laboratory, this figure will be almost doubled. It is our primary reliance to keep pace with the numerically superior research establishments in Germany which are provided military objectives by the famous German flyer, General Udet, and on which the Germans are relying to maintain and retain supremacy in the air wars.

While the Langley Memorial Laboratory is our outstanding institution devoted exclusively to fundamental aeronautical research, several of our larger universities, such as the Massachusetts Institute of Technology, California Institute of Technology and the University of Michigan, have important laboratories and are devoting much time and effort to particular phases of aeronautical scientific problems. The Bureau of Standards is another Government agency which has done much scientific research on problems closely related to the aeronautic science.

Fields in aerodynamics now receiving serious consideration, according to an eminent aeronautic authority, are the problems of air flow at the speed of sound and the peculiar phenomena and the aerodynamic characteristics exhibited, particularly in the high-speed wind tunnels, as the planes approach the speed of sound.

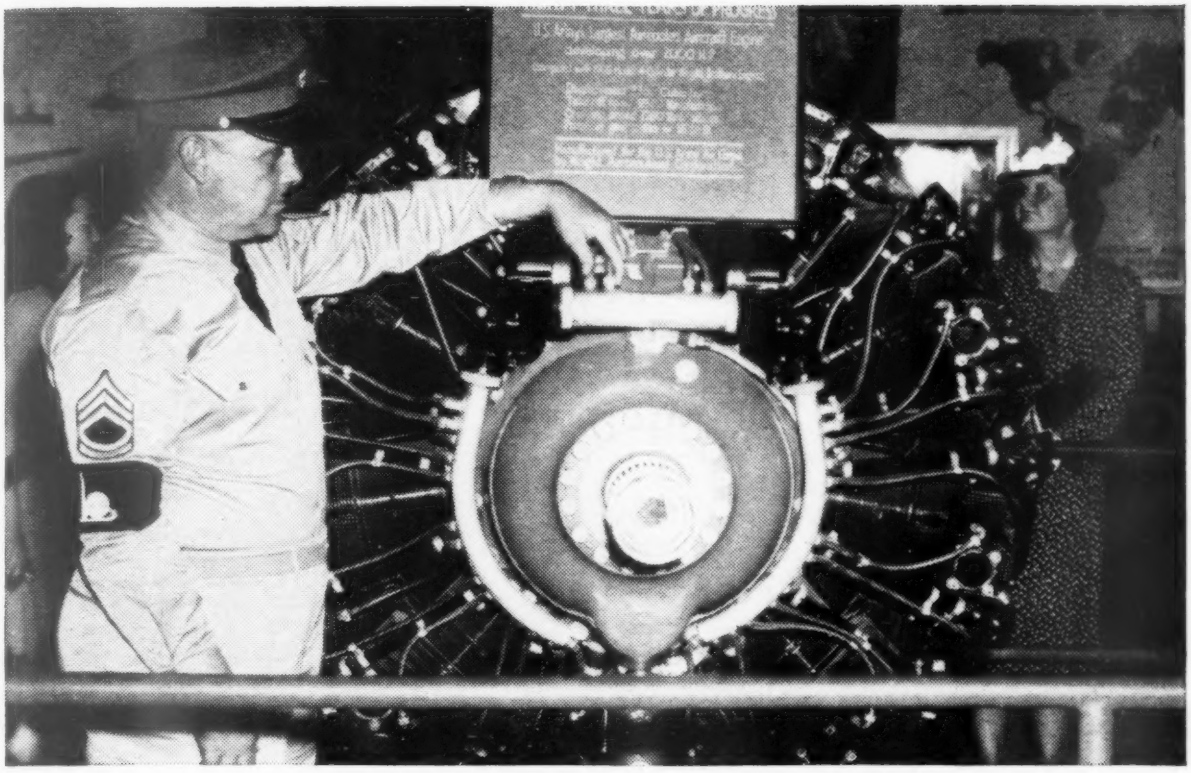
We come now to the institutions which take the basic discoveries from the scientists and turn them from fine metal fabric into completed airplanes and engines.

THE MATERIEL DIVISION OF THE ARMY AIR CORPS

At Wright Field, Dayton, O., stands the Army's experimental aviation center, the Matériel Division. It has long held definite distinction as one of the principal aeronautical experimental centers in the world. It is devoted, with few exceptions, to "applied" rather than "fundamental" research problems. It consists of a series of laboratories equipped and designed and operated by trained and skilled technicians to supervise the development of superior fighting planes.

The exceptions are those problems concerned with the peculiar requirements of military aircraft that have no application or counterpart in commercial aircraft.

There is the airplane division, which busies itself with



Important to the U. S. Army Air Forces was the development of this 2,000 h.p. Wright "Duplex Cyclone," already used in the B-19. Civil and Army engineers already are working on engines of 3,000 h.p. and over.

studies in airplane design and with tests of airplane structures. This laboratory initially receives all new designs submitted to the War Department for forward-looking experimental aircraft. This branch also makes experimental airplane contracts with established manufacturers for production of types of aircraft embodying the new discoveries coming out of the laboratories of the National Advisory Committee.

The airplane branch has a Structures Division which completes the breakdown tests on new models to determine whether strength factors have been met. It tests to destruction the principal parts of all new aircraft before the test pilots take the completed model for trial runs over speed courses.

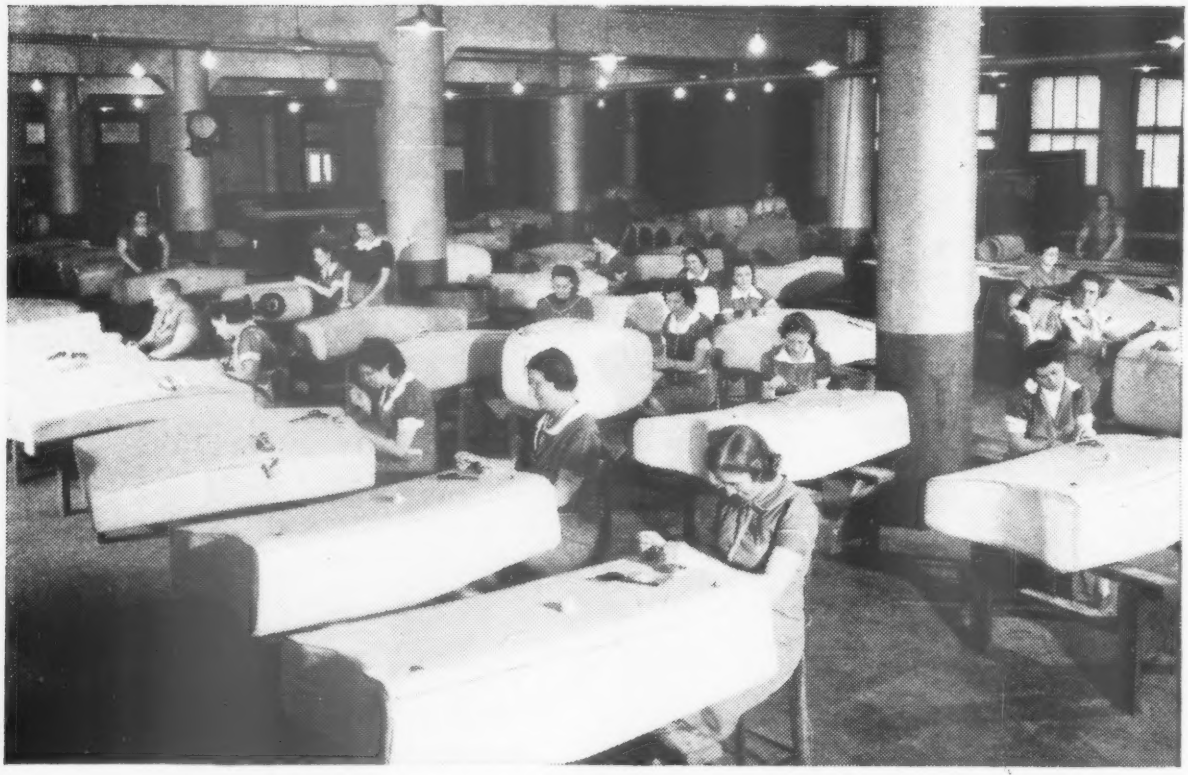
Another equally important laboratory at Wright Field is the Power Plant Division with its separate sections devoted to testing the design of engines and their accessories. At present it is the largest and most complete engine test laboratory in this country. The aircraft engine industry will be the first to say that this institution supported by the Army Air Corps, has made possible the tremendous strides during the last few years in engines of ever-increasing size and reliability. Every inventor who submits a new engine idea to the Army knows that it will go promptly to this laboratory and receive a thorough, impartial trial. The power plant division has been first to test the barrel engine, the flat engine, air-cooled engines of 2,000 and 3,000 h.p., the "W" engine of multiple banks, better propulsion and many another newcomer to the power plant field during the years from 1917 to the present time. To this laboratory go promptly foreign engines. In the first World War all the power plants available from the foreign nations who were Allies, and engines which powered captured planes, went promptly to the Army's experimental engine laboratory to determine whether they contained any advances in new ideas or metals.

Many a struggling inventor with a good idea who cannot raise the large sums required for experimental engine construction has found that our experimental division will take up his problems, have them incorporated in trial engines and built to the inventor's specifications. No other advance has contributed so directly to the progress and speed, range and size of aircraft as has the advent of new and ever more powerful aircraft engines.

While the two or three outstanding civil aircraft engine manufacturers in this country have carried their share of the load in experimentation and development, they have used the laboratories at Wright Field freely and have found the skill and experience located there ever interested and on the alert to help them through their problems.

Every engine intended for use in military aircraft is tested on the stands at Wright Field and nursed through long hours of trial runs. Before any engine is accepted by the Government it must pass a 150-hour endurance test, part of which is at the maximum horsepower output. It is a killing, grueling grind, but from it come the dependable power plants required for Army fighting planes.

The equipment laboratory, part of the Matériel Division experimental department, has been responsible for the development of many new devices now considered essentials in aircraft equipment and manufacture. It has tested all of them. The problems of automatic control, blind-fight instruments, blind-landing equipment, earth inductor compasses and pressurized cabin equipment; these and countless others were tried out and proved or developed and first installed on military aircraft under the supervision of this laboratory. There are sections which have been largely responsible for the development of pilot clothing, parachutes, goggles, oxygen equipment, photographic equipment and many other adjuncts and accessories without which military presonnel could not operate effectively at the speeds and altitudes now required, and without which the airplanes and the engines could not be controlled and directed.



Direct result of lesson learned from current war, U. S. planes now incorporate leak-proof tanks. In this Akron factory, women workers are assembling tanks which Army claims are the best in the world.

The armament section of the experimental laboratory, although by the nature of its work devoted exclusively to equipment for the military establishment, has, in close co-operation with our Army Ordnance Department, been responsible for the adaptation of the present powerful and effective guns, pyro-technics and chemical equipment, gun sights, bombsight and armor plating found in our Army airplanes. Here are tested all foreign cannon, machine guns, bombs, fuses, flares and other items of ordnance, to make sure that no trick of the trade is known or employed abroad which has any superiority over our practices and principles. An important late development conducted by this laboratory, as a case in point, is its tests during the fall of 1940 of armor and bulletproof and self-sealing tanks. Limited tests have been in progress for many years on this subject, but since it appeared from captured German planes that pilot armor, bulletproof glass and leakproof or bulletproof tanks were a part of German aircraft, the efforts of this laboratory were redoubled to match or surpass foreign progress in these fields. It is divulging no secret to say that our modern fighting planes, as they roll from our factories, will be equipped with armament, armor and tankage having no superior in any of the foreign air powers. Our self-sealing tanks can be penetrated by a 50-caliber bullet that crashes through two sides, but the hole seals itself with little if any loss of gasoline and very little chance of fire.

The accuracy of gunfire from aircraft and the accuracy of bombs dropped from airplanes are dependent not alone on the training of operating personnel, but also and perhaps to a greater degree upon the sights, the release mechanisms, the controls and the turrets from which or by means of which these missiles are discharged. These matters are of grave concern to our air force. They determine its power, its precision and efficiency, thus emphasizing the importance of this branch of our experimental laboratories.

The propeller experimental laboratory has been engaged in increasing the size and improving air screw efficiency and in the application of new metals and materials to propeller construction at a time when it was practically the only agency in this country doing this work. It has maintained a leading position in the propeller field. On its torque stands have been tested every propeller developed in this country suitable to military aircraft and every foreign propeller obtainable. It has experimented with new metals, with wood, fabric and many plastics in propeller construction to the end that no other country, so far as is known, can quite match our development in this tremendously important accessory aeronautical field.

The flight test branch of the Air Corps experimental laboratory has flown all experimental military aircraft since before the first World War. There is a long list of intrepid test pilots whose premature deaths are attributable to their willingness for human sacrifice on the experimental field of honor. Many of our flying fields in the Army Air Corps have been named from this gallant little band. The first and many other members of the Caterpillar Club have been Army test pilots who leaped from broken planes in trial flights. No other flying organization in the world has so many firsts to its credit as the flight test section at Wright Field. Its pilots have held more of the World's records for speed, altitude, endurance than any other group of flying men in this country or abroad.

Now, today, as piloting has settled largely to routine air discipline and formula, a group of 20 to 30 pilots at Wright Field day after day go through the gruelling task of testing new airplanes, putting them through their early paces, proving their flight reliability.

The history of the Matériel Division at Wright Field is the history of military air progress in this country. There have been those who have charged that this progress should have been faster. The principal answer to these harping critics is to point out that in spite of the lean years, when this country

The Army Air Forces owe much to the airlines and the CAA for their valuable work in establishing the world's finest airport and airways system. The airlines are vital transportation system in wartime.

made very little money available for our experimental division, we can point with pride to the results achieved and improvements made. No critic has ever been able to show that maximimum effort was not obtained from the funds which the country was willing to devote to aeronautical experimental development as expressed in the annual appropriations from Congress.

It is not a personal bias, but personal knowledge that permits the statement that America owes more to the Army's Air Corps experimental division at Wright Field for its present high place in world air leadership than to any single institution or group in this country.

THE NAVY AIRCRAFT FACTORY AND TESTING STATIONS

The Navy air arm has done much experimentation and development, particularly with large flying boats, adapting their power plants, accessories and equipment to meet aircraft carrier requirements. It has also established an enviable leadership in the development of mechanisms such as arresting gears, catapults and other devices for floating airdromes. The naval air arm and the Army Air Corps have co-operated freely and frankly for the mutual exchange of all developments. Of late, as the experimental institutions of the services expanded and as the pressure of the emergency dictated new economies, the Army and Navy flying branches have divided experimental projects wherever possible. As a case in point, it was agreed not long ago that the Navy would supervise the Diesel engine development. The general principle has been followed that whatever experimental device or item of equipment was most closely related to a particular branch of the service, that branch would supervise its development and make available to the other any progress made, or any resulting new discoveries or developments.

The widespread standardization of engines, materials, processes and accessories by the Army and Navy has helped tremendously in securing quantity production during this period when maximum efficiency is required.

THE AIRCRAFT MANUFACTURERS

The principal manufacturing establishments of the civil air industry have conducted much experimental development. This includes not alone the airplane manufacturers, but the engine manufacturers, the builders of instruments and the suppliers of fuel and lubricants. There are those who have contended that the civil industry should bear the lion's share of the load in aeronautical experimentation. There is an easily ascertainable reason to the contrary. At the close of the first World War, airplane establishments which had expanded to turn out many thousand airplanes per year, in one case as many as 100 airplanes per day, promptly, after the Armistice, saw their contracts canceled. The average number of airplanes ordered both by the Army and Navy and by civil agencies and export, for the 10 years succeeding the Great War, was less than 1,000 planes per annum. It was not economically possible for an aircraft industry of that size and income to support large research staffs devoted to experiments in production methods.

Now with business, domestic and foreign, for the aeronautic industry running to a figure of nearly $5,000,000,000 annually, the industry is meeting the challenge for mass production, with each of the principal manufacturers providing large experimental and engineering staffs devoted both to production methods and the improvement of quality.

The Army and Navy systems of procurement tend to encourage work in this latter field. Airplanes are bought for the armed services largely on a competitive basis. The manufacturer which can demonstrate the best new design with performance gets the business. It therefore behooves the aircraft manufacturers to maintain a sufficient design staff to make certain that its airplanes are superior. The same is true in the airplane engine field and in accessories and equipment. There

are no monopolies. The Army and the Navy buy the best airplane obtainable at the cheapest price possible.

DEPARTMENT OF COMMERCE AND THE AIRLINES

No review of aeronautical experimental facilities in this country would be complete without a careful survey of the purely civil aviation establishments of our Government.

Aeronautical development includes development of airline transportation operational methods and procedure and the provision of adequate airports and airways. The military establishments owe much to the Civil Aeronautics Board of the Department of Commerce and the leading American airlines for valuable work in these fields. The Civil Aeronautics Board has made pre-eminent studies in the field of safety of flight, accident investigation and accident prevention. The transcontinental and intercontinental airlines have evolved, through a period of 10 remarkable years, new operational systems which are of great value to the military establishments since they permit the rapid movement of air forces from base to base and from one geographical section of the country to another. Our Government, through several of its Federal agencies, CAA and WPA particularly, has made permanent advances in airport layout and construction. These agencies have also built more than 300 fields, always with an eye to their possible utility by the military air forces. This is an outstanding contribution to national defense.

The civil airways which link our great cities had early requirements for night lighting beacons, radio transmitting stations and other aids to aerial navigation. These also are usable by military planes and aid mobility of the air forces.

On the other hand, the developments at Wright Field not purely military in character have been made readily available to the civil air operators. They have incorporated promptly the new engines, the new propellers, the new landing gears, the new instruments, the new accessories which have been brought to maturity in the Army's experimental plants.

ALLIED RESEARCH AND EXPERIMENTATION

Several military organizations other than those enumerated have made outstanding contributions to the science of aviation. The Army's Signal Corps has been responsible, in cooperation with the Army Air Corps, for many of the communication devices now so essential in modern air operations. Its great laboratory at Ft. Monmouth spent a large proportion of its funds and time in the development of air signal equipment and accessories. In addition, the Signal Corps established as a branch of the Matériel Division, Wright Field, a signal section devoted exclusively to the improvement of aircraft radios and radioactivated instruments. One lesson which definitely has come out of the current wars in Europe is the absolute necessity for reliable communication between planes in flight and from planes to ground.

The Army Ordnance Department which supplies the Army with its guns, bullets, shells and powder, has joined eagerly and efficiently in the proper equipment of air weapons. It has developed the cannon and machine guns which now equip our planes. It has developed the bombs which are dropped. It has developed the flares by which our bombers see their targets and illuminate their bombing objectives. It has developed many of the sighting and control mechanisms which make these instruments effective weapons.

Our Chemical Warfare Service, mindful of the fact that chemicals played an important part in the first World War and notwithstanding the fact that they have not been used extensively to date, continued to adapt chemicals to aircraft, just in case. The chemical laboratories at Edgewood Arsenal have spent much time and money in equipment aboard aircraft for the discharge of smoke and for chemicals with greatest efficiency and safety to aircraft personnel.

The Army Medical Corps joined military aviation in the early days, first in an effort to perfect systems and devices for the economic determination of those who could fly or be taught to fly, without the costly and dangerous method of trial and error. Today, the Army Medical Corps examines all our prospective flyers and makes semiannual examination of all our flying personnel. It has developed many original devices for accomplishing these purposes. At Wright Field, Dayton, O., it has maintained a Physiological Research Laboratory which is the outstanding institution of its kind anywhere in the world. It has made original studies and determinations on the effects of flying, the effects of extreme altitudes and the effects of noise and strain on flying personnel. It has developed new and excellent oxygen apparatus and has co-operated in the production of the pressurized cabin.

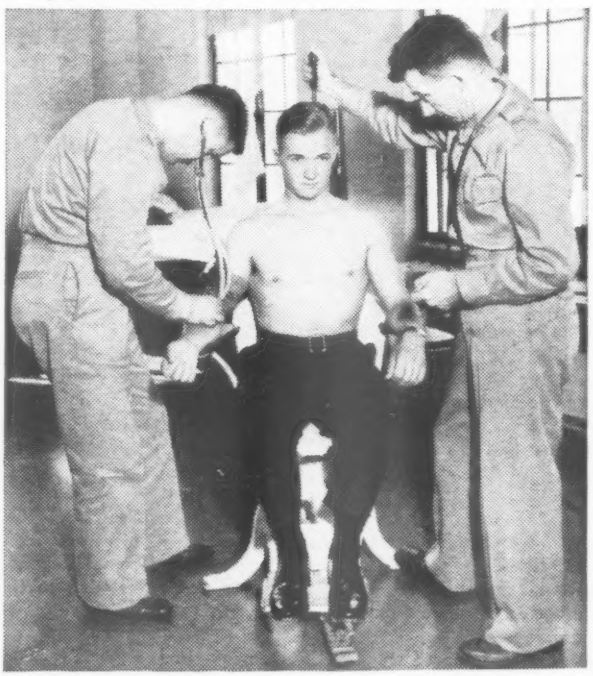
The development by the Flight Surgeons of the Army Medical Corps, in close co-operation with the Army Air Corps' experimental laboratories, of suitable ambulance aircraft, of litters for use in aircraft and for the conversion of airplanes for the transport of sick and wounded, is another important undertaking of the flying doctors.

The Physiological Research Laboratory at Wright Field has made some invaluable studies on the presence of toxic gases in aircraft, by-products of aircraft engine operation.

For a long time it was thought that all that was required to preserve the life and health of the flyer at extreme altitudes was an adequate supply of oxygen. The experiments of the doctors at Wright Field showed that this was not the case. The maintenance of sea level pressure is equally, if not more important than a permanent supply of oxygen to prolong the life and health of the flyer.

The French found at the outbreak of the present war that it was necessary to relieve the combat crews of fighting aircraft every month or six weeks, because of the loss of efficiency and physical breakdown from hours spent at 20,000, 25,000 and 30,000 feet. Our own medical officers in their experiments have shown the loss of control of faculties by men at the higher altitudes. Our medical scientists know the physiological reasons for this and they have taken the lead in the development of pressurized cabins as the only suitable

Army's flight surgeons have learned safe limits for pilots' physical strain. They are shown examining a future cadet.



The gigantic Douglas B-19, today's largest airplane, will be excelled by tomorrow's planes, now being designed. Experiments like the B-19, while expensive, help develop even better types.

answer. In a similar manner, the engineering bureaus of the Navy, the steel, the aluminum, the electrical, the oil industry and the many specialty manufacturers have made equally important contributions.

QUALITY VS. QUANTITY

A discussion which of late has occupied the minds of the military logicians, upon which experimental development has a tremendous bearing, is the argument between quantity and quality. There is a school of air thought which holds that it is better to have a few superior airplanes than large numbers of inferior airplanes.

A German air general when reminded recently that the *Spitfire* was proving more than a match for the Messerschmitt, is alleged to have replied, "We know it. But we have a thousand Messerschmitts to every hundred Spitfires. We figure if the first Messerschmitt is not successful or even if the second falls, the third will overcome its enemy."

It is probable that the truth of this argument between quantity and quality will be found somewhere near the middle ground. It has been shown definitely in the air wars thus far that an airplane considerably inferior to those it will meet in the skies is practically worthless. On the other hand, a few hundred very superior airplanes eventually will lose against an unlimited number of a considerably inferior type. Sufficient of the superior ones will be lost in combat, in landing accidents, or be worn out through the normal wear and tear of service, so that their total effect will eventually be nullified. There is another factor too frequently overlooked in this argument. Quality must be sacrificed somewhat if it prevents quantity production, for it is not alone the numbers on the flying fields today, but the numbers which can be kept coming up from the factories, which will eventually prevail.

The production of aircraft in quantity should not be delayed too long awaiting the perfect article, for never has there been an airplane put into quantity production when there was not an experimental airplane already in the air or just around the corner. The true answer probably is this: at a given time, when the necessity for sufficient aircraft to equip all tactical units arrives, put into production the best airplanes of the types required which are available. Thereafter, on that type, stop all changes and discontinue every improvement which would interfere in any way with the production of that type in quantity. The new experimental plane of higher performance should be rushed to early completion, thoroughly tested, and then it, too, should be put in quantity production, to go to the fighting units as replacements for the older, inferior plane.

Tomorrow's airplane is on the drawing board and in the laboratories today. The military leaders, the aircraft designers and officials of leading aircraft manufacturing establishments know all about it. They know the engines it will have, the propellers which will pull it through the air, what it will weigh, what its wing spread will be, the guns and bombs it will carry —everything down to the last detail. But a year hence, or even five years from now, when it first takes the air, it will be a startling new creation to the rest of mankind. The public will call it tomorrow's airplane.

We could describe in rather intimate detail the Army Air Corps plane of every type which one, two, or three years hence will replace those now believed to be modern fighting planes which are in the hands of our tactical units. That must for the moment remain a secret. Our guessing would be too close to actuality. It would not be disclosing too much of a military secret to say, however, that our fighters will be smaller and faster. They will in the course of routine operations approach, or possibly exceed the present world speed record—400, 450, m.p.h. and yes, even more. Our heavy bombers will be larger, many times larger than any airplane which as yet has been seen in the world. The 40,000-pound *Flying Fortress* will grow into a giant of 200,000

or more pounds of intricate machinery capable of spreading death and destruction 5,000 miles away from its base.

All our multi-engine craft will have the pressure cabins, the instruments and equipment and power plants greatly to exceed today's maximum altitudes. Substratosphere flying will move toward stratosphere flying. Present ranges will seem puny. The power of these new weapons will be doubled many times, for they will carry new and heavier guns. They will carry ammunition loads and bomb loads which now seem impossible.

All this raising of the lid of the treasure chest of the air for the future will be made possible by the scientists, the designers, the engineers and the test pilots. It will move from fancy to fact, from dreams to accomplishment, as a result of aeronautical research, experimentation and development.

Chapter Ten

AIR FORCE FOR US

"I should like to be able to offer the hope that the shadow over the world might swiftly pass. I cannot. The facts compel my stating, with candor, that darker periods may lie ahead."

—Franklin D. Roosevelt, President (Message to Congress, September 21, 1939)

THE temperament of the American people, as reflected in appropriations of the last Congress, seems to indicate that we are to be prepared for those darker periods which our President warns may lie ahead. If this be the case, if our national leaders have received a mandate from the people to build adequate defensive establishments for the United States, then a national program or plan must be followed. Here are some facts and suggestions which bear upon this problem.

WHAT WE NOW HAVE

It is of primary importance that we evaluate accurately what we now have, the point from which we must start. Our Navy has an efficient air service, our Army now has 42 observation squadrons of co-operative aviation to work directly with its land components. In addition, our Army has about 1,500 training planes which are in daily use at its flying schools.

Funds were appropriated from 1939 through 1940 for an additional 21,000 planes and for the equipment for 288 combat squadrons. Those 21,000 planes will give us nearly 10,000 trainers and slightly more than 10,000 combat planes of all types. This will equip the 288 squadrons with modern combat aircraft and will leave a reserve capable of supplying almost one complete replacement.

That is not a large air force measured by standards of modern warfare. It is not as large as the German or the British. It will be third among the world's air forces.

Standing behind that fighting air complement, we have schools capable of turning out 10,000 mechanics and 5,000 pilots a year. By midsummer, 1941, these schools will have a capacity of 20,000 mechanics and 12,000 pilots. Behind the flying line stands an aircraft industry now capable of producing about 1,2000 planes per month and which, by late in 1942, will be producing about 3,000 planes per month.

By way of air bases, three new ones are now nearing completion, the Northeast, Southeast and Northwest in the United States, with three additional ones in Puerto Rico, Panama and Hawaii. We have a total of 19 permanent air bases and 23 temporary air bases, the latter of which are now being hastily constructed and occupied.

The Congress appropriated funds for the Civil Aeronautics Authority for the establishment of civil flying schools for the elementary training of 50,000 pilots. It also made funds available for the improvement of about 100 landing fields so that they will be available as temporary air bases and as dispersion fields.

ORGANIZATION

A sound organization, as is evidenced in the present war, greatly promotes the building of an air force and its efficiency. It promotes, also, the facility with which it may be supplied, equipped, and operated efficiently under war pressure.

Many feel that eventually the defensive air component of the nation will be given a status co-ordinate and commensurate with that of the Army and Navy. When that time will come, if it does come, is not yet clear. We shall be fortunate if our time for that reorganization comes in the relative calm of peace or at worst, in the preparatory and not in the fighting stage. Those changes are always more efficient if they can be made calmly and when there is adequate time.

The separate air force idea must not be approached with the state of mind that everything now in existence, or which has been done is wrong. The Army and Navy, the older services, deserve great credit for the tremendous strides they have made in the development of military and naval aviation. There are many essential services which older and established bureaus, departments, or subdivisions of the Army and the Navy now perform for the air arm.

It may be that eventually air forces for all countries will be separated from land and sea forces for the same reasons that sea and land forces were separated more than a century ago. There is as much diversity in equipment, strategy, technique and leadership between air and land or sea operations as between land and sea fighting. It requires a different type of fighting man operating in a different type of vessel, differently equipped, differently trained over a long period of time and instilled with different ideas of technique, tactics and strategy.

This long step should be taken, if it is taken at all, only after careful planning and mature thought and not with a zest for radical reform. There should be a stage of gradual evolution as against an overnight cutting of binding ties.

In the light of European battlefields, it appears that our squadron, group and wing organizations are sound. When our air force grows to giant size more comparable with the air forces abroad, it will be necessary to do as they have done, to create air divisions and air fleets.

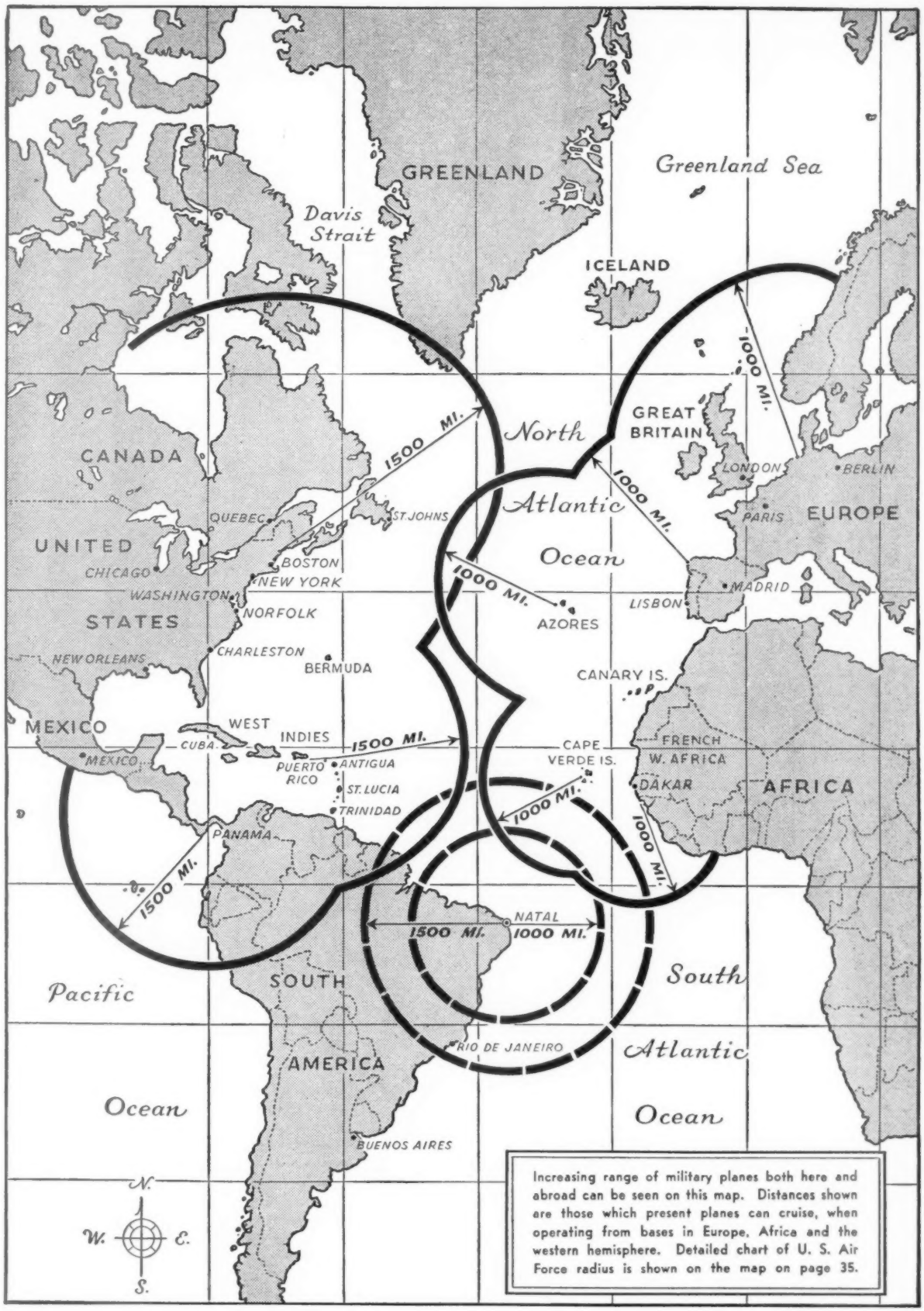
Present experience in Europe points clearly to the wisdom of separation of air fighting echelons into three subordinate commands, the fighter command, the bomber command and the home defense command. These are three radically different air tasks requiring different equipment and different concepts of tactics and strategy. Here again we can wisely emulate the British military model.

The recent institution of air districts as territorial commands is sound, particularly for the supervision of training and the co-ordination of many ground functions and base duties. These, for air forces, play the same role as Corps Area commands have played in peacetime for our land army. They are similar in their duties and responsibilities to the naval districts, long familiar to the naval arm.

The requirements of hemisphere defense and a study of German and British air operations indicate the importance of unified command in task forces. If it ever became necessary for a part of our military forces to go to the defense of a beleaguered hemisphere neighbor, a supreme commander should be named. First, there would be a determination by the high command as to whether the undertaking had a more important and relatively larger air phase or sea or land phase. This determination would indicate the selection of the supreme commander. After the highest command had made a determination as to the ratio of forces, land, sea and air, which would be required for the operation, those forces would be separated from their establishments and organized into a task force. Thereafter, it would be a unified command completely under the jurisdiction and control of the task force commander. Thus would be accomplished the unity of command which is one of the primary lessons many of our military leaders have drawn from close observation of recent conflicts.

SIZE AND COMPOSITION

Before it is possible to say with assurance what the size and composition of our air force should be, some determinations must be made. First, when will that air force be required? Second, where will it be needed? Third, who are the enemies which it will operate against and with what will they be



Increasing range of military planes both here and abroad can be seen on this map. Distances shown are those which present planes can cruise, when operating from bases in Europe, Africa and the western hemisphere. Detailed chart of U. S. Air Force radius is shown on the map on page 35.

equipped? A survey of world conditions today indicates rather clearly that we must match in size and efficiency and surpass, if possible, the largest air force which could be brought against us. The present range of aircraft indicates that the line of approach to us is more likely to include aircraft from floating bases or from land bases temporarily established within striking distance of our shores. The time factor is more difficult to evaluate. During 1939 and 1940, the speed with which nations were ravaged makes it apparent that the briefest possible time in which we can build an air force will not be too soon to have one ready at hand. If the Battle of Britain turns favorably to our mother country, such an air force in our hands will be a tremendous diplomatic weapon at the peace tables. If it turns unfavorably, it will be imperative that there exist in the Western Hemisphere an air force of sufficient power, speed, range and performance to match the air forces which will be riding high in the Eastern Hemisphere.

How large should that air force be? There is a general agreement now that the present size of our air armaments is deficient. It is not unlikely that Germany has an air force of at least 7,000 combat planes in fighting units, with two or three times that number in reserve. Her allies can possibly raise that figure to 12,000 first-line aircraft. We are now launched on expansion programs for which funds have already been appropriated which will give us 4,000 combat planes in the hands of tactical squadrons and another 5,000 in reserve in our Army. There will be another 6,000 with our Navy. Those planes will not be completed before the early summer of 1942. Prior to that time a determination must be made as to whether that force is sufficient. Our Army will then have 288 fighting squadrons of all types. That is a wise first step toward an ultimate objective. Further study may make it necessary to increase that to a total of at least 400 squadrons divided, perhaps, into 100 heavy bomber squadrons, 100 medium and light bombardment squadrons, 100 fighter squadrons of all categories and 100 squadrons of miscellaneous types—transport for parachute troops and air infantry, for ambulances and for the delivery of fighting cargoes, the supply of air troops. Among these latter 100 squadrons will be also the reconnaissance squadrons, long and medium ranged, for scouting and the supply of air intelligence. These 400 squadrons should be able to implement hemisphere defense to meet effectively the air forces now rampant in the world which we may conceivably be forced to meet in the skies somewhere above the Western Hemisphere.

It is not possible to predict accurately the types of planes and size, fire power, speed and range, for any long period. Conditions in the air realm change so quickly, the discoveries and accomplishments of science and industry are so rapid, that the indomitable flying fortress of today may have to be withdrawn from the air fighting a few months hence for lack of speed, ability to reach a sufficient altitude, or because of inferior armament or armor.

This much is certain, however: the prime characteristic of fighter planes, their speed and multiple gun power, must be kept abreast and if possible superior to that found elesewhere in the world. The great strain on the human physique incident to fighting at altitudes above 20,000 feet, points clearly to the desirability of the development of the pressurized cabin.

The clearest lesson which has been written in the skies concerning the bomber in recent air warfare is the fact that range is of tremendous importance. The heavy bomber should be able to reach any part of the enemy territory so that it can threaten with destruction the building of armaments in any section of the enemy nation. The range of heavy bombers in all the forces of the world has been much too restricted. Our heavy bombers must exceed the range of enemy aircraft if that desirable end is attainable. If we have that superior performance, the bases from which any foreign aircraft could be launched against us can be destroyed or harassed by our bombers before enemy planes can be brought within range of our critical areas. Name our enemy with definiteness and one can say with assurance what the range of our bombers should be. Within three to five years, there is every probability that this range must be between 8,000 and 12,000 miles. This requires an air vessel of tremendous size measured by our present standards. The largest production bombers at the present time do not exceed 60,000 pounds in weight. The 10,000-mile bomber will of necessity be an airplane of 100,000 pounds with some as large as 200,000 pounds.

Thus far, airplanes for the most part have been operated by single crews. A definite determination can now be reached that the airplane can be made ready for a second mission before its crew can be sufficiently rested to operate with efficiency. This indicates the necessity for multiple crews. It is not unlikely that there will be required pilots, bombers, gunners, navigators and radio technicians to three times the number of fighting aircraft available.

The necessity for multiple crews and the predicted expansion of our air force point to the requirements for additional aviation schools for combat and maintenance crews. Our present objective of a capacity in our schools of 20,000 mechanics and 12,000 pilots a year may require additional enlargement. A per annum capacity of 50,000 mechanics and 50,000 combat crew men is not beyond the possibility of our accomplishment and appears reasonable as a wartime requirement.

The combat training of our air fighters is now proceeding along modern lines. The changes in technique and tactics, demonstrated as necessary in late air engagements, are being applied as rapidly as possible to the training programs of our tactical units. There must be continued stress on this program and some phases of training must receive increased emphasis. The slogan of the Combat Command, to "fly, bomb and shoot" must never be forgotten. Adequate bombing and gunnery ranges must be provided so that all combat crews will fly, bomb and shoot every week of every year. Only by actual use of modern weapons can the required degree of efficiency be attained.

Lack of sufficient co-operative aviation in the past, as well as the shortage of motorized, mechanized forces in the ground branches, has led to insufficient co-operation between aviation and the motorized forces to insure the degree of training and efficiency indicated as necessary by the campaign in Poland. Steps have already been taken to remedy this deficit and ever-increasing emphasis must be placed on full-scale maneuvers between the airman and the soldier in the tank or combat car.

It has been demonstrated more than once in Europe in recent months that there are frequent episodes in combat when there must be thorough co-operation between air forces and sea forces. It appears likely that any task force organized incident to the requirements of hemisphere defense will be made up of all three of the principal arms, land, sea and air. This indicates the necessity for more frequent joint problems between the Army and Navy and the Army Air Forces and the surface fighting elements.

LEADERSHIP

A matter of concern to thoughtful airmen is the question of military air leadership. It is impossible for any organization or activity which has existed but one generation to have inculcated the principles of leadership in any large numbers of its officers.

Success in air battles, success in building up air power, will depend in a large degree on the quality of leadership. The number of men who have trained for a period of 25 to 30 years in military air organizations is extremely limited—not more than 500. This small group, augmented by a few outstanding men in civil aviation, alone has the experience to be our air leaders in the preparation, planning and building of this greatly enlarged air force.

Judging by the trends in Germany and in England, there is a new conception for age in air leadership. The air generals

abroad average about 45 years of age. There is a definite tendency toward more rapid promotion in the air arms and an insistence on relatively young men in high places. Also the higher wastage rate in active air operations makes for quicker advancement. This question of age in leadership is one for serious consideration by any nation now determined to build a great air force along new and modern lines.

One requirement for leadership in the air, which has been held to steadfastly, is that of the flying leader for flying men. It starts with the lowest unit, the squadron, and runs to the highest unit in most of the foreign air forces. It is contended that in no other way can proper morale be maintained and proper knowledge and experience be developed for leadership in the flying arm.

CIVIL PHASES

An air force is of little value, no matter what its size, unless it be kept modernized. An air force will not be long of value in the heat of war unless there is adequate provision for supplying the wartime battle wastage rate. The obsolescence factor in aircraft is largely due to the ever-recurring model of superior performance and design. Aircraft losses in air warfare between two equally matched air powers will probably be no less than 25 per cent a month and it may be as great as 50 per cent a month.

All this points to the fact that the second line of planes is of almost equal importance to the first line. The first line is the air force in being, the second line is the reserve and aircraft industry.

Our aircraft industry possesses possibilities superior to any other in the world. That is demonstrably true by the fact that our aircraft always have had superior performance and foreign markets have always preferred our planes and engines. It is hinted anew by the avidity with which foreign nations now engaged in war's struggle buy our military planes.

The only matter for grave concern is whether or not our industry can be built to sufficient proportions to develop and maintain an adequate air force and do it in time. Plans are now in progress for the development of an aircraft industry in this country capable of producing 36,000 planes a year. That might not be enough. In the event of a war between the United States and a coalition of the leading powers of the world now unsympathetic to our Government and our economic policy, it is quite possible that an aircraft capacity of more than 50,000 planes a year might be brought against us.

That means that by 1942, when we have reached our 36,000 plane rate, we might have to double it. It is better, unless war is imminent, in the meantime to perform that expansion by gradual steps and thus avoid the hectic period of mushroom growth such as we witnessed in the first World War. There are those who believe that the aircraft industry as it now exists, composed of men who have been brought up and trained in aircraft design, in engineering, in shop management and in production methods, should continue to supervise this expansion, that it should be built around them, that they should be the seed for the new giant plant. Others profess to believe that allied mechanical producers, such, for example, as the automobile industry, should be called in and set to augment the overworked aircraft industry.

We believe that a compromise, as is the usual American way, will be the eventual solution. Experience, already, in the aircraft industry is being spread thin indeed. Those 32,000 skilled workmen, engineers and designers, who comprised the personnel of the aircraft industry in 1938, have in the short period of two years been increased to more than 150,000. If we are to go to a production of 50,000 per annum, it would be necessary to more than double that figure. This means that only one man in nine in the aircraft industry will have had an experience of more than a few months.

On the other hand, the British or shadow-factory scheme where widely separated plants, usually with no prior aircraft experience, are set to building vital components of the airplane, with their assembly elsewhere, is fraught with many dangers. It has been pointed out that it took four years to make the scheme workable in England and even there the production rate generally is not believed to exceed 2,000 planes per month at the end of that four-year period of pressure trial.

It is useless to build a vast horde of fighting planes unless they are supplied with the military equipment, the guns, the bombs, the ammunition, the radio, the navigational instruments and the many other accessories to make them fighting weapons. This problem will require definite planning and strong governmental leadership, plus the complete co-operation of private industry.

There is another civil phase in this air business of primary importance, too, and that is the question of civil morale under air attack. The value of stout morale has been demonstrated recently to the whole world in the Battle of Britain. Wars are fought to bring pressure on peoples so that they will demand of their leaders a cessation of hostilities, no matter what the cost.

There are many ways for maintaining high morale even under this new pressure attack of modern air forces. Propaganda and public education will play prominent roles. The people must believe in the justice of their cause. They must believe in the soundness of their leadership. They must continue in the hope that victory will be the ultimate result.

The accomplishment of all these objectives dictates the cleverest use of that new weapon in warfare called propaganda. The word propaganda usually carries an evil stigma, a bad odor. It need not. There can be education for good as well as evil. It behooves our nation to develop these agencies for education and for the dissemination of news to the fullest extent.

High morale is extremely difficult to maintain after bombs begin to fall in the streets in quantity, unless there is organization and planning to insure air-raid shelters, blackouts, prompt repair of bomb damage, adequate fire fighting—in short, rigid civil discipline. Have we that civil discipline now? Can we build it up in time? The selective service training now about to be put into operation will go a long way to build it up.

The provision of an adequate air force will be a strong factor in maintaining civil morale. It was true in the first World War that our troops on the front line, although machine-gunned by enemy planes, were of high spirit and morale when our own fighters promptly shot down the enemy marauder attacking them. It has been reported that now in England there is a smile on British faces when the invading bomber is violently attacked by British fighters. Bombs may have dropped, houses may have burned, but the homeless will look skyward with renewed resolution as long as their own fighting planes are tearing into every attacker.

The sound of friendly antiaircraft guns is a wonderful palliative to the nerve-racking screech of the air-raid siren. A people like to know they are giving blow for blow. When it appears that defenses are poorly organized or inadequate, that leadership is uncertain, it will be difficult to maintain civil morale at the requisite level for effective resistance.

It has been charged that we have been lax in civil training for air defense. Our deficiencies may have been largely because the air attack appeared far distant. It requires time, much planning and the provision of much ground equipment, this business of indirect air defense, and it is too late to wait until enemy bombers can be heard overhead to begin this important phase of training and preparation. Blackouts should be practiced seriously in all our cities. Provision should be made for the rapid installation of air-raid shelters, warning devices and a full complement of antiaircraft defense.

The part which commercial aviation plays in warfare is too frequently not clearly understood. There are conflicting views which need to be compromised. There are those who feel the commercial airplane can be made a satisfactory military weapon by hasty improvisation. There are others who contend that increased numbers of civil airlines will be required for the carrying of mail, valuable cargo and passengers in

warfare and that these planes will be unavailable to augment the military air forces.

Both of these views are in part correct. The civil air transport is not a military weapon and cannot be changed to a satisfactory fighting craft. It must, however, be used for ambulance purposes, for freight and troop transport, for carrying officials, dispatches and mail and in many other important ways. Such service will be augmented, not decreased, under war conditions. Furthermore, a thriving civil airline industry has airports which can be used by the military and trained mechanics and pilots which could be used in event of dire emergency to operate and maintain fighting planes. It calls for the building of airways with facilities which are equally usable by squadrons and groups for rapid transfer from one air theater to another.

A most important use of commercial aviation lies in the fact that it is a vital customer to air industry. There will be periods in peacetime when the military consumer will be a poor customer. Relying upon him alone, the air industry would be forced to dangerous deflation. New civil uses for aircraft are developing daily. It behooves us to stimulate the use of the airplane commercially in order that there may be a market for the industry to keep it in being in safe size in peace periods.

The operation of commercial international airlines is invaluable to a nation which may have to wage intercontinental warfare. The British have reported that the presence in their country of a German airline during the years of peace preceding the present war now is aiding the Germans tremendously in the location of targets.

Foreign airlines will be established, linking our shores and our principal cities with the rest of the world, unless we are there first with American airlines and unless we operate those airlines so efficiently and so successfully as to drive the foreign competitor from the field. An important element of national defense lies here. It must not be overlooked.

A definite national plan, thoroughly prepared, publicly announced and followed implicitly, is an absolute essential to adequate air defense. This must include not only the actual development of the air force, the schools for the training of its technicians, the factories for the building of its planes, the provision of adequate appropriations to pay the bill, but it concerns many other phases of national life.

We have had in this country many plans for the production of airplanes in a given number and for the formulation of an air force of a certain size. None of these plans has ever been long maintained and each has concerned only airplane numbers and air force size.

A real national plan would co-ordinate every phase of the air industry, every phase of civil life relating to aviation, and integrate these with our whole existence. In Germany, as an example, all the highways are constructed with a view to their utility for the transport of armies and as well for the conversion of certain sections into wartime landing fields. It is doubtful whether, in either of the nations now engaged in a life-and-death struggle, a single dollar of public funds has been spent without the national defense angle being carefully considered. Funds spent for public works, funds expended for relief, are potential assets for the provision of adequate defense.

A national air plan should include also protection for factories and industrial establishments. If included in the original factory plan, many devices can be incorporated which will make the factory represent a poor target for enemy air bombardment. They can be camouflaged, shutter arrangements can be included for instantaneous blackout. They could, at considerable additional cost, be built underground. Certainly they can be located geographically where they will be less exposed.

The principal thing about a well-defined plan, which should be widely publicized and made known to the whole people, is that it will unify them, give them a common purpose. It will furnish a focal point toward which all can work toward a common desire, the provision of adequate defense for them, their homes and their country.

William B. Courtney, writing in *Collier's Weekly* on how to build an air force, said:

> Those of us who have seen the German Navy, Army and Air Force, know that whatever else may divulge, Chancellor Hitler's real 'secret weapon' is team work; attained to a degree never before seen in military operations.
>
> It permeates the entire organization from General Staff to lowliest squad; it ties the fighting man to home industrial backgrounds, civilians, farmers and squires.

The building of an adequate air force will require the expenditure of vast sums. It will require the co-ordinated effort of many thousands of citizens and heavy taxation for all of them. Popular support cannot be maintained over the long period of time required for the completion of such an effort unless we have a definite program and strong, able leadership.

We are blessed more than any nation with all the basic essentials required in the building of a superior air armament. It but remains for us to demonstrate that we have the requisite national will, the universal public determination to have one. National defense in reality is a national state of mind. All of our citizens must be imbued with an intelligent concern for the safety of their country and with a firm determination to maintain its safety.

It is now apparent, as the world rides toward the middle of the twentieth century, that air forces may completely disrupt nations; that air forces can dictate terms at peace tables; that the threat of air forces can accomplish without dropping a bomb the breakdown of opposing diplomatic morale. There are abroad in the skies of this troubled world tremendous air forces of remarkable power and efficiency. It is unlikely that a nation such as ours can maintain its integrity and continued existence in its present way of living unless it establishes and maintains the world's strongest air force.

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THE END